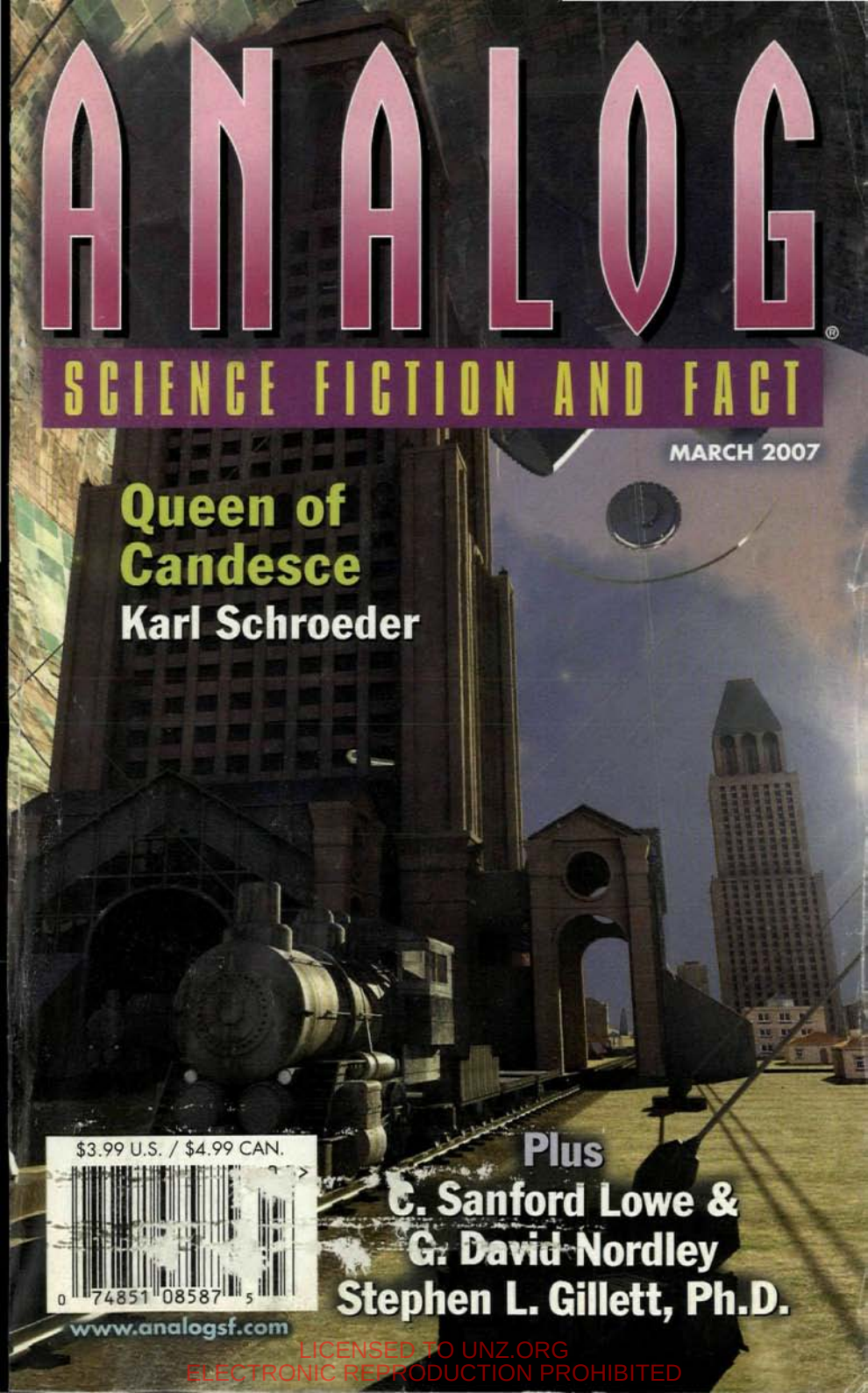

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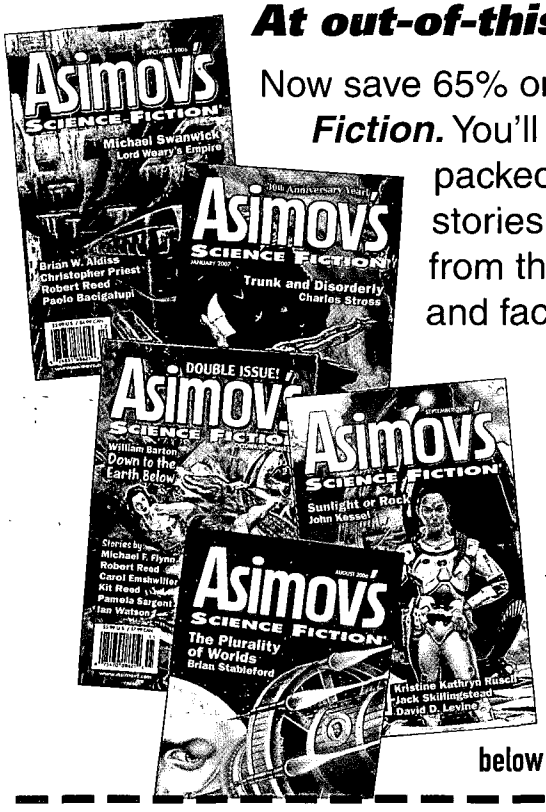

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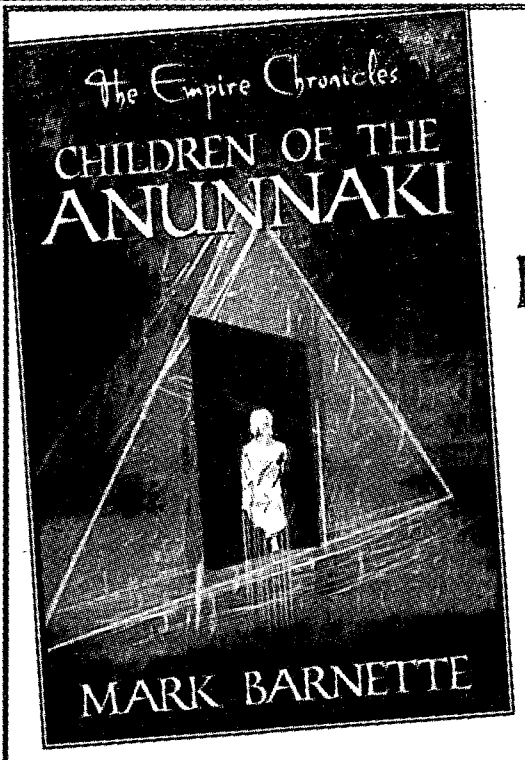

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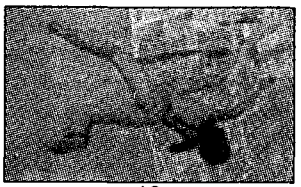

10

72

SERIAL

QUEEN OF CANDESCE, part I of IV, Karl Schroeder ____ 10

NOVELLA

THE SMALL POND, C. Sanford Lowe & G. David Nordley ____ 100

NOVELETTE

COOL NEIGHBOR, Michael Shara & Jack McDevitt ____ 86

SHORT STORIES

TRUCKS, Amy Bechtel ____ 67
MISQUOTING THE MOON, David Bartell ____ 72

SCIENCE FACT

TOWARD A NOT-JUST-DIAMOND AGE, Stephen L. Gillett, Ph.D. ____ 54

READER'S DEPARTMENTS

THE EDITOR'S PAGE ____ 4
IN TIMES TO COME ____ 99
THE ALTERNATE VIEW, John G. Cramer ____ 83
THE REFERENCE LIBRARY, Tom Easton ____ 134
BRASS TACKS ____ 139
UPCOMING EVENTS, Anthony Lewis ____ 144

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Indicia on Page 5

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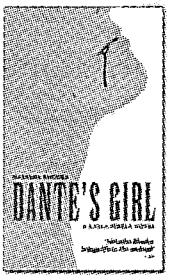

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EDITORIAL Stanley Schmidt

NEW WRITERS

Last summer a thread on the *Analog* website Readers' Forum revisited a frequently asked question: What determines whether a story submission gets bought, and how can an aspiring writer improve his or her chances of selling? Several of our regular contributors joined in and did an admirable job of setting the record straight for those participating. However, the number of our readers who are interested in writing is much larger than the number who frequent the Forum. Since the Forum comments repeat a number of common and counterproductive misconceptions and speculations, I thought it would be a good idea to respond to some of them here, too.

For example, the thread started with a reader questioning the statement in our submission guidelines (available on our website [www.analogsf.com] or by sending a request with a self-addressed stamped business-size envelope) that "*Analog* will consider material submitted by any writer, and consider it solely on the basis of merit. We are definitely eager to find and develop new, capable writers." This reader did his own research by counting stories in our 2005 issues and identifying those writers he thought were new. His identifications were not always accurate, but his qualitative observation that only a minority of stories were by new authors is true. Unfortunately, he then concluded, "Seems like *Analog* might be considering more than just the merit of the stories they receive. Looks like you need to have some publishing experience listed in your cover letter."

Which is, as several other participants (both professional and otherwise) pointed out, very wrong.

The fact is that the author's name, reputation, or publishing history has *absolutely no effect* on our decision about whether to buy a story. Please note that I speak here only for *Analog*; magazine editors are quirky individuals just like everybody else, and different ones can and do have different priorities. And *book* publishing is a quite different kettle of fish. If a novel is published in book form, the success of that book is riding on a single story. The publisher will want to make sure it sells at least reasonably well, and there is a good deal of evidence that many book purchases are made in large part because readers liked previous books by a particular author. So *book* publishers often *do* seek out books by authors who have sold well in the recent past, and sometimes won't even consider manuscripts by authors of recent books that didn't make much money.

At magazines—in particular, at *this* magazine—things are very different. Each issue contains not one, but several stories and other features, so there's not as much riding on any one of them. We can be more willing to take a chance if we're not sure how readers will react to an unusual story. As long as most readers like most of what we publish, they'll allow us an occasional oddity that they don't like. Most of them are intelligent

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and observant enough to realize that individual tastes vary widely, so we can't expect any reader to love everything we publish, or every reader to love anything.

The flip side, of course, is that *most* readers have to like *most* of what we publish, or we'll lose our audience. We can't afford to let that happen, so we are very seriously determined to get the best material we can, regardless of where or whom it comes from. So we really do pick stories "solely on the basis of merit." "Merit," of course, is in part subjective, so what I really mean by the "best" stories is "those stories I think most likely to please most of our readers." But those can come from anywhere. Quite often (and this should surprise no one) they come from people who have already written for us enough to have a good idea of what we're likely to like, and how to create it. But they can, and sometimes do, come from complete newcomers. By at least one measure, the most popular story I've published in all my years of editing *Analog* was a first submission straight out of the slush pile.

So don't names count for anything at all? Well, sometimes, but probably not in the way you might imagine. One person on the Forum asked, "Does *Analog* surreptitiously rely on 'big names' to snag purchases on magazine racks? . . . Some names, at least, are listed on the cover." Oh, come on! There's nothing surreptitious about listing names that are likely to catch a reader's eye on the newsstand; of course we want to do that, and a well-known name is obviously more likely to do it than a completely unfamiliar one. We don't list *all* contributors on the cover (as does that poster, who edits an online magazine) because (a) the familiar ones would stand out less from a long list, and (b) many of our readers like the cover art and want the picture relatively uncluttered. The space constraints and display requirements for an e-zine and a print magazine on a newsstand are entirely different.

But (and this is important) most of our sales these days are through subscriptions, not newsstands, and subscription renewals depend more than anything else on trust. We need subscribers to feel confident that we will give them really good reading material most of the time, and a "big name" on the cover does not automatically assure that. One of the first things I learned when I took this job is that even the biggest names are not in top form all the time. Also, I *can't* buy more than about 1% of what I get, no matter how much I'd *like* to buy, because that's all the magazine has room for. So, just as I have bought and featured stories from complete unknowns, I've also rejected work by almost anybody you can think of.

Now: suppose I buy a substandard or inappropriate story just so we can print a big name on the cover. Maybe it does

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produce a little one-time blip in newsstand sales, but the value of that will be more than offset by the loss of trust when our subscribers read the story inside and feel cheated. We can't afford to let that happen. So instead I buy the best stories I can, from whoever offers them to me. If one of them happens to be from an author with a highly recognizable name, yes, we'll put that on the cover (and when I turn down a story from such an author, no one else needs to know about it). But note carefully that the story is first bought on its own merits, and only then do we consider using the author's name as part of a marketing plan. The name plays no role in deciding whether to buy the story.

We try to keep the *magazine's* name one that readers will recognize and trust as a reliable source of good stories, even to the point where I can give an unknown top billing on the cover and newsstand readers will pick it up because they suspect this must be a new writer of great promise. And yes, this has happened; two cases that come to mind right off the top of my head are David R. Palmer ("Emergence") and Geoffrey A. Landis ("Elemental").

Incidentally, I can think of one small exception to my statement that the author's name has no effect on my likelihood of buying a story: sometimes a good track record can make it *harder* to sell a particular story. I once sent a story back with a letter that began, "If I got this story from somebody I'd never heard of, I'd be very excited. But I know Mike Flynn can do better. . . ." (And with that goad, he did.)

Let's look at another sadly amusing myth from that website thread: "'Open to new writers' is just a marketing gimmick . . . It's the oldest trick in the publishing book. Hopefuls subscribe to the magazine because they figure they'll want a copy when their stuff is published. *Analog*'s subscription base would be decimated if they told the truth about their story selection process." I have no idea what basis this writer thinks he has for believing such fanciful "facts," but the truth about our story selection process is what I'm telling now and always have. If we publish your story, you don't need a subscription to get a copy—we'll automatically *give* you a couple of copies, along with actual payment in currency of the realm, plus the option of buying as many additional copies as you may want

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at a substantial discount. And while our subscriber base includes a good many writers who submit stories, it includes a great many more readers who have no interest in submitting.

Another attempt to bolster the tired old rationalization that rejection or sale is determined by name: one writer on the Forum said a story by a "name" recently appeared in *Analog* with the same premise as one of his that we'd rejected. I don't doubt it, and I was pleased and impressed that the writer had the good grace not to accuse anyone of plagiarism or even to name the other story or author with a similar idea. Another of the first things I learned when I took this job is that truly, completely new ideas are extremely rare. A premise does not make a story; the story is what you *build* on the premise, and evidently I liked one of these more than the other. Some premises have served as the basis for several successful stories and hundreds or even thousands of unsuccessful ones. Some years back I published a list of 26 that I could count on seeing in my slush pile several times every *month*, but once in a great while a skilled writer (like Orson Scott Card) can still turn one of those into a fresh and memorable story. But doing that takes skill, and that takes both talent (the raw material from which skill can be made) and practice.

Incidentally, I should probably say a few words about the "slush pile," since I've mentioned it a couple of times and many people think it sounds derogatory and make still more assumptions about what it means. In my case, all manuscripts come to me in an unsorted pile and I read them all—all 500 or so that I get in a month. If you do the math, it will be obvious that I don't read them all the same way. If I'm going to get through them all, I'll have to read most of them quite rapidly, so I try to do that with all of them. But I can't speed-read something that grabs my concentrated interest, so if that happens while I'm working through that initial "slush pile," I put that story aside for reading later in a different, much slower, and more analytical mode. Often, when I get a new pile of manuscripts, I'll flip through it right away and pull out some that I know I'll have to read in slow mode, because of past experience with that author. That does not mean that stories in that "pro pile" are automatically given preference come buying time; it just means that, statistically, I know it's going to take longer to go through a foot of those than a foot of "slush." But if there's something of pro quality in the slush pile, by somebody I've never heard of, it will leap out at me and I'll pull it out for a closer read later.

And that's the biggest kick I ever get in this job: the thrill of discovery, of finding my attention completely captivated by a really good writer the rest of the world doesn't know about yet.

So you bet I want to find and cultivate new writers—and I need to, because the ones I've already cultivated tend to attract other editorial eyes and get book contracts that keep them too busy to write much short fiction. But that doesn't mean I'm interested in publishing writers just *because* they're new. I'm no more interested in publishing new writers *per se* than in publishing "big names" *per se*. I'm interested in publishing *stories* that make our readers sit up and take notice. At any given time, a majority of those stories are likely to be by writers who already have some experience—but some won't be. And some of those few writers who catch my eye for the first time will be the "big names" newcomers envy a few years later.

Remember, *everybody* was a newcomer, an unknown, initially. Getting beyond that stage requires a certain amount of talent, a lot of persistence, and (it must be admitted) a certain amount of luck. I've spent quite a bit of time trying to debunk the myth that newcomers don't have a chance; now I must balance the picture with a few

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words about the countermyth that if you have some talent and are persistent enough, eventually you will succeed. Sadly, it isn't necessarily so. "Merit," as I mentioned earlier, is partly subjective; most editors are trying to match reading material with sets of readers who will enjoy it, and they have quite different audiences. You should *never* assume that just because a story doesn't sell to one market, it's "no good" in some objective sense. Get it out to other markets and see if you can find one that wants to buy what you're trying to sell. Maybe you will; maybe you won't. That depends on there being a suitable market at the right time, with the right kind of vacancy, not having bought something too similar too recently, etc., etc. My personal record is 21 years, for a story that I recognized as a "Twilight Zone" story as soon as I wrote it, but couldn't sell until somebody started a "Twilight Zone" magazine. As an editor, I've read lots of perfectly respectable stories that may never see print because their authors may not live long enough to find the right home for them.

But some will, and it's enough fun that if your interests run that way, I certainly encourage you to give it your best shot. Don't give up your day job unless and until it feels really right; don't let your whole future happiness and sense of self-worth depend on commercial success as a writer; but tell the stories you have to tell as well as you can tell them. Remember that merit isn't *all* subjective; this trade, like any other, depends on skills that you need to develop, and you may not be able to tell whether you have them until you do. Learn the basics, like submission protocol and grammar (you'd be astounded at how few people use commas and hyphens in a way much better than random, and at how much you can make yourself stand out by becoming one of them). Be aware that the competition is *tough*—but if you do well at it, it can offer you rewards (largely intangible, though occasionally financial as well) that you'd be hard put to find anywhere else.

And besides, I want to read those stories.

Good luck!■

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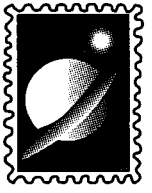

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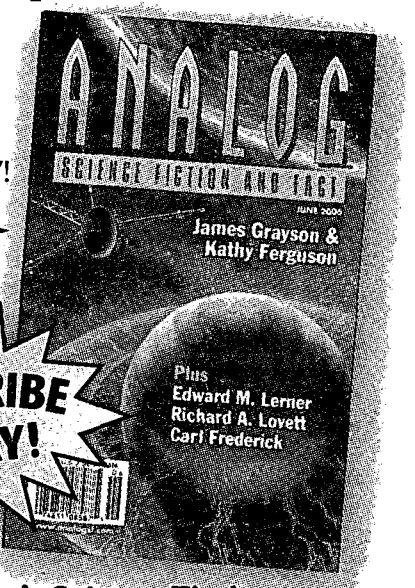

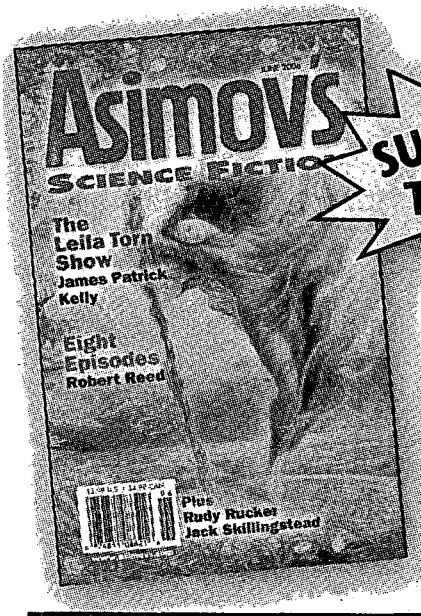

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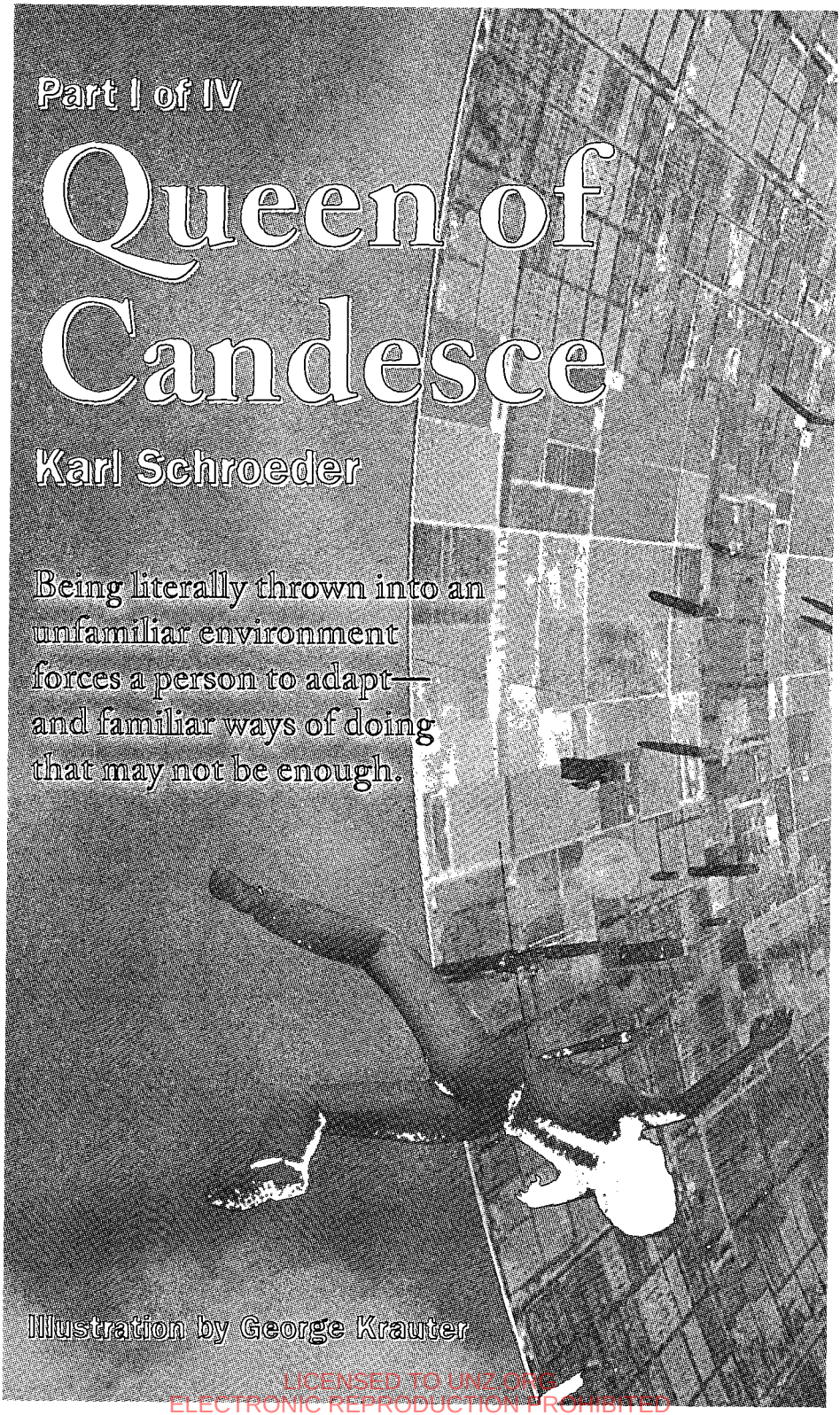
Queen of Candesce

Karl Schroeder

Being literally thrown into an unfamiliar environment forces a person to adapt—and familiar ways of doing that may not be enough.



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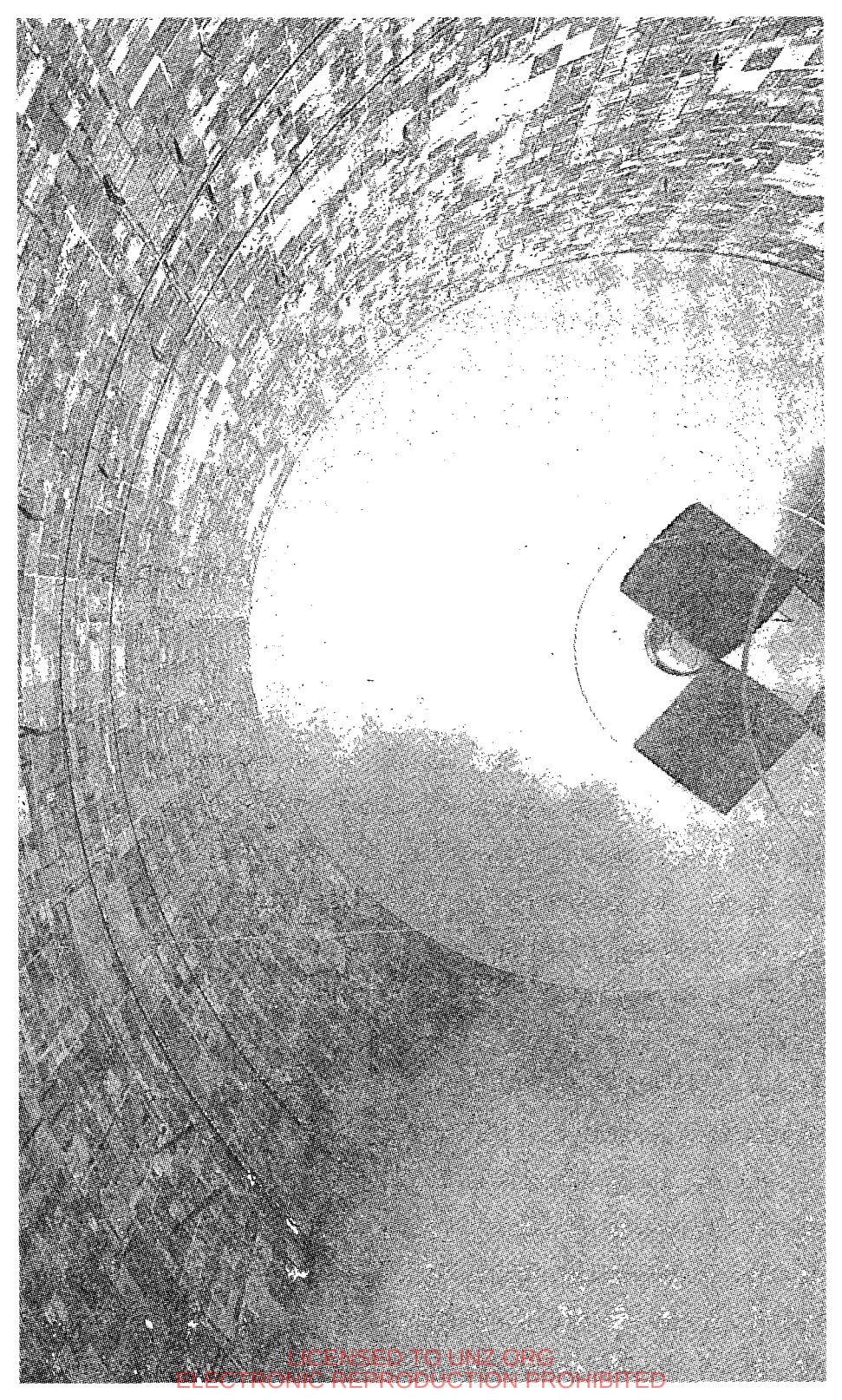

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Prologue

Garth Diamandis looked up, and saw a woman in the sky.

The balcony swayed under him; distant trees wavered in the hot afternoon air though there was no breeze. A twist of little clouds pirouetted far overhead, just beneath the glitter and darkness of the city that had exiled Gareth to this place so many years ago. Well below the city, only a thousand feet up at this point, a single human form had appeared out of the light.

She rotated up out of Garth's view and he had to wait several minutes for her to come back around. Then, there she was: gliding with supernatural grace over the tall, ragged wall that rimmed the world at its nearer end. Behind her, infinite air beckoned, forever out of reach of Garth and the others like him. Ahead of the silent woman, a likely tumble into quickly moving trees, broken limbs and death. If she wasn't dead already.

Someone tried to escape, he thought—an act that always ended in gunshots or bloody thrashing beneath a swarm of piranhawks. This one must have been shot cleanly by the day watch for she was spiraling across the sky alone, not attended by a retinue of blood droplets. And now the spin-gale was teasing the fringes of her outlandish garment, slowing her; bringing her down.

Garth frowned, for a moment forgetting the aches and pains that bedeviled him all day and all night. The hovering woman's clothes had been too bright and fluttered too easily to be made of the traditional leather and metal of Spyre.

As the world turned the woman receded into the distance, frustrating Garth's attempt to see more. The ground under his perch was rotating up and away along with the whole cylindrical world; the black-haired woman was not moving with it but rather sailing in majestically from one of the world's open ends. But Spyre made its own winds as it turned, and those winds would pull her to its surface before she had a chance to drift out the other side.

She would have sped up by that time, but not enough to match Spyre's rotation. Garth well knew what happened when someone began clipping the treetops and towers at several hundred miles per hour. He'd be finding pieces of her for weeks.

The ground undulated again. Frantic horns began echoing in the distance—an urgent conversation between the inner surface of Spyre and the city above.

Watching the woman had been an idle pastime, since it looked as though she was going to come down along the rail line. People with more firepower and muscle than Garth owned that; they would see her in a few moments and bring her down. Her valuable possessions and clothes would not be his.

But the horns were insistent. Something was wrong with the very fabric of Spyre, an oscillation building. He could see it in the far distance now: the land heaved minutely up and down. The slow ripple was making its way in his direction; he'd better get off this parapet.

The archway opening onto the balcony had empty air behind it and a twenty-foot drop to tumbled stones. Garth hopped over the rail without hesitation, counting as he fell. "One pilot, two pilot, three—" He landed among upthrusts of stabbing weed and the cloud-like brambles that had taken over this ancient mansion. Three seconds? Well, gravity hadn't changed, at least not noticeably.

His muscles creaked as he stood up, but climbing and jumping were part of his daily constitutional, a grim routine aimed at convincing himself he was still a man.

He stalked over the crackling grit that painted a tiled dance floor. Railway ties were laid callously across the fine pallasite-stones; the line cleaved the former Nation of Arbath like a whip-mark.

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Garth stepped onto the track daringly and stared down it. The great family of Arbath had not reached an accommodation with the preservationists and had been displaced or killed, he couldn't remember which. Rubble, ruins, and new walls sided the tracks; at one spot an abandoned sniper tower loomed above the strip. It swayed now uneasily.

The tracks converged in perspective but also rose with the land itself, a long graceful curve that became vertical if he followed it far enough. He didn't look that far, but focused on a scramble of activity taking place about a mile distant.

The Preservation Society had planted one of their oil-soaked sidings there like an obscene graffito. Some of the preservationists were pouring alcohol into the tanks of a big turbine engine that squatted on the tracks like an idol to industrialism. Others had started a tug and were shunting in cars loaded with iron plating and rubble. They were responding to the codes brayed out by the distant horns.

They were so busy doing all this that none had noticed what was happening overhead.

"You're crazy, Garth." He hopped from foot to foot, twisting his hands together. When he was younger he wouldn't have hesitated. There was a time when he'd lived for escapades like this. Cursing his own cowardice, Garth lurched into a half run down the tracks—in the direction of the preservationist camp.

He had to prove himself more and more often these days. Garth still sported the black cap and long sideburns that rakes had worn in his day, but he was acutely aware that the day had come and gone. His long leather coat was brindled with cracks and dappled with stains. Though he still wore the twin holsters that had once held the most expensive and stylish dueling pistols available in Spyre, nowadays he just carried odd objects in them. His breath ratcheted in his chest and if his head didn't hurt, his legs did, or his hands. Pain followed him everywhere; it had made crow's-feet where once he'd outlined his eyes in black to show the ladies his long lashes.

The preservationist's engine started up. It was coming his way so Garth prudently left the track and hunkered down beneath some bushes to let it pass. He was in disputed land, so no one would accost him here, but he might be casually shot from a window of the train and no one would care. While he waited he watched the dot of the slowly falling woman, trying to verify his initial guess at her trajectory.

Garth made it the rest of the way to the preservationist camp without attracting attention. Pandemonium still reigned inside the camp, with shaven-headed men in stiff leather coats crawling like ants over a second, rust-softened engine, under the curses of a supervisor. The first train was miles up the curve of the world now, and if Garth bothered to look down the length of Spyre, he was sure he would see many other trains on the move as well. But that wasn't his interest.

Pieces of the world fell off all the time. It wasn't his problem.

He crept between two teetering stacks of railway ties until he was next to a pile of catch-nets the preservationists had dumped here. Using a stick he'd picked up along the way, he snagged one of the nets and dragged it into the shadows. Under full gravity it would have weighed several hundred pounds; as it was, he staggered under the weight as he carried it to a nearby line of trees.

She was going by again, lower now and fast in her long spiral. The woman's clothes were tearing in the headwind, and her dark hair bannered behind her. When Garth saw that her exposed skin was bright red he stopped in surprise, then redoubled his efforts to reach the nearest vertical cable.

The interior of Spyre was spoked by thousands of these cables; some rose at low angles to reattach themselves to the

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skin of the world just a few miles away. Some shot straight up to touch down on the opposite side of the cylinder. All were under tremendous tension and every now and then one snapped; then the world ran like a bell for an hour or two and shifted, and more pieces fell off of it.

Aside from keeping the world together, the cables served numerous purposes. Some carried elevators. The one Garth approached had smaller lines draped and coiled around its frayed black surface—some old, rusted, and disused pulley system. The main cable was anchored to a corroded metal cone that jutted out of the earth. He clipped two corners of the roll of netting to the old pulley. Then he jogged away from the tracks, unreeling the net behind him.

It took far too long to connect a third corner of the huge net to a corroded flagpole. Sweating and suffering palpitations, he ran back to the flagpole one more time. As he did she came by again.

She was a bullet. In fact, it was the land that was speeding by below her and pulling the air with it. If she'd been alive earlier she might be dead now; he doubted whether anyone could breathe in such a gale.

As soon as she shot past, Garth began hauling on the pulleys. The net lurched into the air a foot at a time. Too slow! He cursed and redoubled his effort, expecting to hear shouts from the preservationist camp at any moment.

With agonizing slowness, a triangle of netting rose. One end was anchored to the flagpole; two more were on their way up the cable. Had he judged her trajectory right? It didn't matter; this was the only attachment point for hundreds of yards, and by now she was too low. Air resistance was yanking her down, and in moments she would be tumbled to pieces on the ground.

Here she came. Garth wiped sweat out of his eyes and pulled with bloody hands. At that moment the shriek of a steam whistle sounded from the preservationist camp. The rusted engine was on the move.

The mysterious woman arrowed in just above the highest trees. Garth thought for sure she was going to miss his net. Then, just as the rusted engine sailed by on the tracks—he caught snapshot glimpses of surprised preservationist faces and open mouths—she hit the net and yanked it off the cable.

A twirling screw hit Garth in the nose and he sat down. Sparks shot from screaming brakes on the tracks, and the black tangling form of the falling woman passed between the Y-uprights of a jagged tree, the trailing net catching branches and snapping them as she bounced with astonishing gentleness into a bed of weeds.

Garth was there in seconds, cutting through the netting with his knife. Her clothes marked her as a foreigner, so her ransom potential might be low. He probably couldn't even get much for her clothes; cloth like that had no business being worn in Spyre. Oh well; maybe she had some adornments that might fetch enough to buy him food for a few weeks.

Just in case, he put a hand on her neck—and felt a pulse. Garth cursed in astonishment. Jubilantly he slashed away the rest of the strands and pulled her out as a warning shot cracked through the air.

Unable to resist, he teased back the wave of black hair that fell across her face. The woman was fairly young—in her twenties—and had fine, sharp features with well-defined black eyebrows and full lips. The symmetry of her face was broken only by a star-shaped scar on her jaw. Her skin would have been quite fair were it not deeply sunburnt.

She only weighed twenty pounds or so. It was easy to sling her over his shoulder and run for the deep bush that marked the boundary of the disputed lands.

He pushed his way through the

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branches and onto private land. The preservationists pulled up short, cursing, just shy of the bushes. Garth Diamandis laughed as he ran; and for a precious few minutes, he felt like he was twenty years old again.

1

A low-beamed ceiling swam into focus. Venera Fanning frowned at it, then winced as pain shot through her jaw. She was definitely alive, she decided ruefully.

She was—but was Chaison Fanning also among the living, or was Venera now a widow? That was it, she had been trying to get back to her husband, Chaison Fanning. Trying to get home—

Sitting up proved impossible. The slightest motion sent waves of pain through her; she felt like she'd been skinned. She moaned involuntarily.

"You're awake?" The thickly accented words had the crackle of age to them. She turned her head gingerly and made out a dim form moving to sit next to her. She was lying on a bed—probably—and he was on a stool or something. She blinked, trying to take in more of the long, low room.

"Don't try to move," said the old man. "You've got severe sunburn and sunstroke, too. Plus a few cuts and bruises. I've been wetting down the sheets to give you some relief. Gave you water, too. Don't know what else to do."

"Th-thanks." Then she looked down at herself. "Where are my clothes?"

His face cracked in a smile, and for a second he looked much younger. He had slab-like features, with prominent cheekbones and piercing gray eyes. Eyes like that could send chills through you, and from his confident grin he seemed to know it. But as he shifted in the firelight, she saw that lines of care and disappointment had cut away much of his handsomeness.

"Your clothes are here," he said, patting a chair or table nearby. "Don't worry, I've done nothing to you—not out of virtue, mind, I'm not a big fan of virtue, mine or anyone else's. No, you can thank arthritis, old wounds, and age for your safety." He grinned again. "I'm Garth Diamandis. And *you* are a foreigner."

Venera sighed listlessly. "Probably. What does that mean around here?"

Diamandis leaned back, crossing his arms. "Much, or nothing, depending."

"And here is . . . ?"

"Spyre," he said.

"Spyre . . ." She thought she should remember that name. But Venera was already falling asleep. She let herself do it; after all, it was so cool here . . .

When she awoke again it was to find herself propped half upright in a chair. Her forehead, upper body, and arms were draped with moist sheets. Blankets swaddled her below that.

Venera was facing a leaded-glass window. Outside, green foliage made a sunlit screen. She heard birds. That suggested the kind of garden you only got in the bigger towns—a gravity-bound garden where trees grew short and squat, and soil stayed in one place. Such things were rare—and that, in turn, implied wealth.

But this room . . . As she turned her head her hopes faded. This was a hovel, for all that it too seemed built for gravity. The floor was the relentless iron of a town foundation, though surprisingly she could feel no vibration from engines or slipstream vanes through her feet. The silence was uncanny, in fact. The chamber itself was oddly cantilevered, as though hollowed out of the foundations of some much larger structure. Boxes, chests, and empty birdcages were jammed or piled everywhere, a few narrow paths worn between them. The only clear area was the spot where her overstuffed armchair sat. She located the bed to her left, some tables, and a fireplace that looked like it had been clumsily dug into the wall by the window. There were several tables here and the clutter had infected them as well; they were covered with framed

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pictures.

Venera leaned forward, catching up the sheet at her throat. A sizzle of pain went through her arms and shoulders, and she extended her left arm, snarling. She was sunburned a deep brick red, which was already starting to peel. How long had she been here?

The pictures. Gingerly, she reached out to turn one in the light. It was of a young lady holding a pair of collapsible wrist-fins. She wore a strange, stiff-looking black bodice, and her backdrop was indistinct but might have been clouds.

All the portraits were of women, some two dozen by her estimation. Some were young, some older; all the ladies seemed well-off from their various elaborate hairdos. Their clothes were outlandish, though, made of sweeping chrome and leather, clearly heavy and doubtless uncomfortable. There was, she realized, a complete absence of cloth in these photos.

"Ah, you're awake!" Diamandis shuffled his way through the towering stacks of junk. He was holding a limp bird by the neck; now he waved it cheerfully. "Lunch!"

"I demand to know where I am." She started to stand and found herself propelled nearly to the ceiling. Gravity was very low here. Recovering with a wince, she coiled the damp sheet around her for modesty. It didn't help; Diamandis frankly admired her form anyway, and probably would have stared even if she'd been sheathed in plate armor. It seemed to be his way, and there was, strangely, nothing offensive about it.

"You are a guest of the Principality of Spyre," said Diamandis. He sat down at a low table and began plucking the bird. "But I regret to have to inform you that you've landed on the wrong part of our illustrious nation. This is Greater Spyre, where I've lived now for, oh . . . twenty-odd years."

She held up the picture she had been looking at. "You were a busy man, I see."

He looked over and laughed in delight. "Very! And why not? The world is full of wonders, and I wanted to meet them all."

Venera touched the stone wall and now felt a faint thrum, but very slight. "You say this is a town? An old one . . . and you've turned gravity way down." Then she turned to look at Diamandis. "What did you mean, 'regret to inform me'? What's wrong with this Greater Spyre?"

He looked over at her, and now he seemed very old. "Come. If you can walk, I'll show you your new home."

Venera bit back a sharp retort. Instead, she sullenly followed him through the stacks. "My temporary residence, you mean," she said to the cracked leather back of his coat. "I am making my way back to the court at Slipstream. If ransom is required, you will be paid handsomely for my safe return . . ." He laughed, somewhat sadly.

"Ah, but that it were possible to do that," he murmured. He exited up a low flight of steps into bright light. She followed, feeling the old scar on her jaw starting to throb.

The roofless square building had been built of stone and steel I-beams, perhaps centuries ago. Now devoid of top and floors, it had become a kind of open box, thirty feet on a side. Wild plants grew in profusion throughout the rubble-strewn interior. The hole leading to Diamandis's home was in one corner of the place; there was no other way in or out as far as she could see.

Venera stared at the grass. She'd never seen wild plants under gravity before. Every square foot was accounted for in the rotating ring-shaped structures she called towns. They were seldom more than a mile in diameter, after all, often built of mere rope and planking. There was no other way to feel gravity than to visit a town.

She scanned the sky past the stone walls. In some ways it looked right: the endless vistas of Virga were blocked by

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some sort of structure. But the perspective seemed all wrong.

"Come." Diamandis was gesturing to her from a nearly invisible set of steps that ran up one wall. She scowled, but followed him up to a level area just below the top of the wall. If she stood on tiptoe, she could look over. So she did.

Venera had never known one could feel so small. Spyre was a rotating habitat, like those she had grown up in. But that was all she could have said to connect it to the worlds she had known. Diamandis's little tower sat among forlorn trees and scrub-grass in an empty plain that stretched to forest a mile or more in each direction. In any sane world, this much land under gravity would have been crammed with buildings; those empty plazas and tumbled-down villas should have been awash with humanity.

Past the trees, the landscape became a maze of walls, towers, open fields, and sharp-edged forests. And it went on and on to a dizzying, impossible distance. Diamandis's tower was one tiny mote on the inside surface of a cylinder that must be ten or twelve miles in diameter and half again as long.

Sunlight angled in from somewhere behind her; Venera turned quickly, needing the reassurance of something familiar. Beyond the open ends of the great cylinder, the reassuring cloudscapes of the normal world turned slowly; she had not left all sense and reason behind. But the scale of this town-wheel was impossible for any engineering she knew. The energy needed to keep it turning in the unstable airs of Virga would beggar any normal nation. Yet the place looked ancient, as evidenced by the many overgrown ruins and furzes of wild forest. In fact, she could see gaps in the surface here and there through which she could glimpse distant flickers of cloud and sky.

"Are those holes?" she asked, pointing at a nearby crater. Leaves, twigs, and grit fogged the air above it, and all the topsoil for yards around had been stripped away revealing a stained metal skin that must underlie everything here.

Garth scowled as if she'd committed some indiscretion by pointing out the hole. "Yes," he said grudgingly. "Spyre is ancient and decaying, and it's under an awful strain. Tears like that open up all the time. It's everyone's nightmare that one day, such a rip might not stop. If the world should ever come to an end, it will start with a tear like that one."

Faintly alarmed, Venera looked around at the many other tears that dotted the landscape. Garth laughed. "Don't worry, if it's serious the patch gangs will be here in a day or two to fix it—dodging bullets from the local gentry all the while. They were out doing just that when I picked you up."

Venera looked straight up. "I suppose if this is greater Spyre" she said, pointing, "then that is Lesser Spyre?"

The empty space that the cylinder rotated around was filled with conventional town-wheels. Uncoupled from the larger structure, these rings spun grandly in midair, miles above her. Some were 'geared' towns whose rims touched, while others turned in solitary majesty. A puff of smaller buildings surrounded the towns.

The wheels weren't entirely disconnected from Greater Spyre. Venera saw cables standing up at various angles every mile or so throughout the giant cylinder. Some angled across the world to anchor in the ground again far up Spyre's curve. Some went straight past the axis and down to an opposite point; if you climbed one of these lines, you could get to the city that hung like an iron cloud half a dozen miles above.

She didn't see any elevator traffic on the nearest cables. Most were tethered inside the maze-like grounds of the estates that dotted the land. Would anyone have a right to use those cables but the owners?

When Diamandis didn't reply, Venera glanced over at him. He was gazing up

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at the distant towns, his expression shifting between empty adoration and anger. He seemed lost in memory.

Then he blinked and looked down at her. "Lesser Spyre, yes. My home, from which I am exiled for life. Always visible, never to be achieved again." He shook his head. "Unlucky you to have landed here, lady."

"My name," she said, "is Venera Fanning." She looked out again. The nearer end of the great cylinder began to curve upward less than a mile away. It rose for a mile or two, then ended in open air. "I don't understand," she said. "What's to prevent me—or you—from leaving? Just step off that rim yonder and you'll be in free flight in the skies of Virga. You could go anywhere."

Diamandis looked where she was pointing. Now his smile was condescending. "Ejected at four hundred miles per hour, Lady Fanning, you'll be unconscious in seconds for lack of breath. Before you slow enough to awake you'll either suffocate or be eaten alive by the piranhawks. Or be shot by the sentries. Or be eviscerated by the razor wire clouds, or hit a mine . . .

"No, it was a miracle that you drifted unconscious through all of that, to land here. A once-in-a-million feat.

"Now that you're among us, you will never leave again."

Diamandis's words might have alarmed Venera had she not recently survived a number of impossible situations—not only that, he was manifestly wrong about the threat the piranhawks represented; after all, hadn't she sailed blithely through them all? These things in mind, she followed him down to his hovel, where he began to prepare a meal.

The bird was pathetically small; they would each get a couple of mouthfuls out of it if they were lucky. "I'm grateful for your help," Venera said as she lowered herself painfully back into the armchair. "But you obviously don't have very much. What do you get out of helping me?"

"The warmth of your gratitude," said Diamandis. In the shadow of the stone fireplace, it was impossible to make out his expression.

Venera chose to laugh. "Is that all? What if I'd been a man?"

"I'd have left you without a second thought."

"I see." She reached over to her piled clothes and rummaged through them. "As I suspected. I've not come through unscathed, have I?" The jewelry that had filled her flight jacket's inner pockets was gone. She looked under the table and immediately spotted something: it looked like a metal door in the floor, with a rope loop as its handle. Her feet had been resting on it earlier.

"No, it's not down there," said Diamandis with a smile.

Venera shrugged. The two most important objects in her possession were still inside her jacket. She could feel the spent bullet through the lining. As to the other—Venera slipped her hand in to touch the scuffed white cylinder that she and her husband had fought their way across half the world to collect. It didn't look like it was worth anything, so Diamandis had apparently ignored it. Venera left it where it was and straightened to find Diamandis watching her.

"Consider those trinkets to be payment for my rescuing you," he said. "I can live for years on what you had in your pockets."

"So could I," she said levelly. "In fact, I was counting on using those valuables to barter my way home, if I had to."

"I've left you a pair of earrings and a bracelet," he said, pointing. There they were, sitting on the table next to her toeless deck shoes. "The rest is hidden, so don't bother looking."

Seething but too tired to fight, Venera leaned back, carefully draping the moist sheet over herself. "If I felt better, old man, I'd whip you for your impudence."

He laughed out loud. "Spoken like a

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true aristocrat! I knew you were a woman of quality by the softness of your hands. So what were you doing floating alone in the skies of Virga? Was your ship beset by pirates? Or did you fall overboard?"

She grimaced. "Either one makes a good story. Take your pick. Oh, don't look at me like that, I'll tell you, but first you have to tell *me* where we are. What is Spyre? How could such a place exist? From the heat outside I'd say we're still near the sun of suns. Is this place one of the principalities of Candesce?"

Diamandis shrugged. He bent over his dinner pot for a minute, then straightened and said, "Spyre's the whole world to those of us who live here. I'm told there's no other place like it in all of Virga. We were here at the founding of the world, and most people think we'll be here at its end. But I've also heard that once, there were dozens of Spyres, and that all the rest crumbled and spun apart over the ages . . . So I believe we live in a mortal world. Like me, Spyre is showing its age."

He brought two plates. Venera was impressed: he'd added some cooked roots and a handful of boiled grains and made a passable meal of the bird. She was ravenous and dug in; he watched in amusement.

"As to what Spyre is . . ." He thought for a moment. "In the cold-blooded language of the engineers, you could say that we live on an open-ended rotating cylinder made of metal and miraculously strong cables. About six miles from here there's a giant engine that powers the electric jets. It is the same kind of engine that runs the suns. Once, we had hundreds of jets to keep us spinning, and Spyre's outer skin was smooth and didn't catch the wind. Gravity was stronger then. The jets are failing, one by one, and wind resistance pulls at the skin like the fingers of a demon. The old aristocrats refuse to see the decay that surrounds them, even when pieces of Spyre fall away and the whole world becomes unbalanced in its turning. When that happens, the preservationist society's rail engines start up and they haul as many tons as needed around the circle of the world to reestablish the balance.

"The nobles fought a civil war against the creation of the preservation society. That was a hundred years ago, but some of them are still fighting. The rest have been hunkered down on their estates for five centuries now, slowly breeding heritable insanities in the quiet of their shuttered parlors. They're so isolated that they hardly speak the same language anymore. They'll shoot anyone who crosses their land, yet they continue to live, because they can export objects and creatures that can only be made here."

Venera frowned at him. "You must not be one of them. You're making sense as far as I can tell."

"Me? I'm from the city." He pointed upward. "Up there, we still trade with the rest of the principalities. We have to, we've got no agriculture of our own. But the hereditary nobles own us because they control the industries down here."

The bitterness in his voice was plain. "So, Garth Diamandis, if you're a city person, what are you doing living in a hole in the ground in Greater Spyre?" She said it lightly, though she was aware the question must cause him more pain.

He did look away before smiling ruefully at her. "I made the cardinal mistake of all gigolos: I cultivated popularity among women only. I bedded one too many princesses, you see. I was kindly not killed nor castrated for it, but I was sent here."

"But I don't understand," she said. "Why is it impossible to leave? You said something about defenses . . . but why are they there?"

Diamandis guffawed. "Spyre is a treasure! At its height, this place was the equal of any nation in Virga, with gravity for all and wonders you couldn't get anywhere else. Why, we had horses!

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Have you heard of horses? And dogs and cats. You understand? We had here all the plants and animals that were brought from Earth at the very beginning of the world. Animals that were never altered to live in weightlessness. Even now, a breeding pair of house cats costs a king's ransom. An orange is worth its weight in platinum. We had to defend ourselves and prevent our treasures being stolen. So for centuries now Spyre has been ringed with razors and bombs to prevent attack—and to prevent anyone smuggling anything out. And believe me, when all else has descended to madness and decadence, that is the one policy that will remain in place." He hung his head.

"But surely one person, traveling alone—"

"Could carry a cargo of swallowed seeds. Or a dormant infant animal in a capsule sewn under the skin. Both have been tried. Oh, travel is still possible, for nobles of Lesser Spyre and their attendants, but there are body scans and examinations, interrogations, and quarantines. And anyone who's recently been on Greater Spyre comes under even more suspicion."

"I . . . see." Venera decided not to believe him. She would be more cheerful that way. She did her best to shrug off the black mood his words had inspired and focused on her meal.

They ate in silence for a while, then he said, "And you? Pirates or a fall overboard?"

"Both and neither," said Venera. How much should she tell? There was no question that lying would be necessary, but one must always strike the right balance. The best lies were built of pieces of truth woven together in the right way. Also, it would do her no good to deny her status or origins; after all, if the paranoid rulers of Spyre needed money, then Venera Fanning herself could fetch a good price. Her husband would buy her back, or reduce this strange wheel to metal flinders. She had only to get word back to him.

"I was a princess of the kingdom of Hale," she told Diamandis. "I married at a young age, he is Chaison Fanning, the admiral of the migratory nation of Slipstream. Our countries lie far from here—hundreds or thousands of miles, I don't know—far from the light of Candesce. We have our own suns, which light a few hundred miles of open air that we farm. Our civilizations are bounded by darkness, unlike you who bask in the permanent glory of the sun of suns . . ."

Some audiences would need more—not all people knew that the whole vast world of Virga was artificial, a balloon thousands of miles in diameter that hung alone in the cosmos. Lacking any gravity save that made by its own inner air, Virga was a weightless environment whose extent could easily seem infinite to those who lived within it. Heat and light were provided not by any outside star but by artificial suns, of which Candesce was the oldest and brightest.

Even the ignorant knew it was a man-made sun that warmed their faces and lit the crops they grew on millions of slowly tumbling clods of earth. But the world itself? One glance up from your own drudge-work might encompass vast, cloud-wreathed spheres of water, miles in extent, their surfaces scaled with mirror-bright ripples; thunderheads the size of nations, which made no rain because rain required gravity but rather condensed balls of water the size of houses, of cities, then threw them at you; and a glance down would reveal depths of air painted every delicate shade by the absorption and attenuation of the light of a dozen distant suns. How could such a place have an end? How could it have been made by people?

Venera had seen the outer skin of the world, watched icebergs calve off its cold black surface. She had visited the region of machine-life and incandescent heat that was Candesce. The world was an artifact, and fragile. In her coat pock-

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et was something that could destroy it all, if you but knew what it was and how to use it.

There were things she could tell no one.

A thing she could tell was that her adopted home of Slipstream had been attacked by a neighboring power, Mavery. Missiles had flashed out of the night, blossoming like red flowers on the inner surface of the town-wheels of Rush. The city had been shocked into action, a punitive expedition mounted with her husband leading it.

She explained to Diamandis that Mavery's assault had been a feint. He listened in mesmerized silence as she described the brittle dystopia known as Falcon Formation, another neighbor of Slipstream. Falcon had conspired with Mavery to draw Slipstream's navy away from Rush. Once the capital was undefended, Falcon Formation was to move in and crush it.

The true story was that Venera's own spy network had alerted them to this plot. Chaison and Venera Fanning had taken seven ships from the fleet and left on a secret mission to find a weapon powerful enough to stop Falcon. The story she told Diamandis now was that her flagship and its escort were pursued by Falcon raiders, chased right out of the lit air of civilization into the darkness of permanent winter that permeated most of Virga.

That had been a month ago.

After that, more things she could tell: a battle with pirates, being captured by same; escape, and more adventures near the skin of the world. She told Diamandis that they had sailed toward Candesce in search of help for their beleaguered country. She did not tell him that their goal was not any of the ancient principalities that ringed the sun. They were after a pirate's treasure, in particular the one seemingly insignificant piece of it that now rested in Venera's jacket. They had come seeking the key to Candesce itself.

In Venera's version, the Slipstream expedition had been met with hostility and chased into the furnace-like regions around Candesce. Her ships had been set upon and half of them destroyed by treacherous marauders of the nation of Gehellen.

In fact, she and her husband had orchestrated the theft of the pirate's treasure from under the noses of the Gehellens and then fled with it—he, back to Slipstream and her, into the sun of suns. There she had temporarily disabled one of Candesce's systems. While it was down, Chaison Fanning was to lead a surprise attack on the fleet of Falcon Formation.

Slipstream's little expeditionary force was no match for the might of Falcon—normally. For one night, the tables should have been turned.

Venera had no idea whether the whole gambit had been successful or not. She would not tell Diamandis—would not have told anyone—that she feared her husband was dead, the force destroyed, and that Falcon cruisers ringed the Pilot's palace at Rush.

"I was lost overboard when the Gehellens attacked," she said. "Like much of the crew. We were close to the sun of suns and as dawn came, we burned . . . I had foot-fins, and at first I was able to fly away, but I lost one fin, then the other. I don't remember anything after that."

Diamandis nodded. "You drifted here. Luckily, the winds were in your favor. Had you circulated back into Candesce you'd have been incinerated."

That much, at least, was true. Venera suppressed a shudder and sank back in her chair. She was infinitely weary all of a sudden. "I need to sleep."

"By all means. Here, we'll get you to the bed." He touched her arm and she hissed in pain. Diamandis stepped back, concern eloquent on his face.

"There are treatments—creams, salves . . . I'm going to go out and see what I can get for you. For now you

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have to rest. You've been through a lot."

Venera was not about to argue. She eased herself down on the bed, and despite being awash in burning soreness, fell asleep before hearing him leave.

2

Near dawn, the lands of Greater Spyre were lit only by the glitter of city lights high overhead. In the faint glow, the ancient towers and forests seemed as insubstantial as clouds. Garth paused in the black absence beneath a willow tree. He had run the last hundred yards, and it was all he could do to keep his feet.

Silhouettes bobbed against the gray outline of a tower. Whoever they were, they were still following him. It was unprecedented: he had snuck through the hedgerows and fields of six hereditary barons, each holding no more than a square mile or so of territory but as fanatical about their boundaries as any empire. Garth knew how to get past their guards and dogs, he did it all the time. Apparently, these men did also.

It must have been somebody at the Goodwill Free Clinic. They'd waited until he was gone and then signaled someone. If that was so, Garth would no longer be able to count on the neutrality of the Kingdom of Hallimel—all six acres of it.

He moved on cautiously, padding quietly onto a closely cropped lawn dotted with ridiculously heroic statues. It was quiet as a tomb here; and certainly nobody had any business being out. He allowed himself a little righteous indignation at whoever it was that was following him. They were trespassers; they should be shot.

It would be most satisfying to raise the alarm and see what happened—a cascade of genetically crazed hounds from the doorway of yon manor house, perhaps, or spotlights and a sniper on the roof. The trouble was, Garth himself was a known and tolerated ghost in only a few of these places, and certainly not the one he was passing through now. So he remained discreet.

A high stone wall loomed over the garden of statues. Its bricks were crumbling and made an easy ladder for Garth in the low gravity. As he rolled over the top he heard voices behind him—someone exclaiming something. He must have been visible against the sky.

He landed in brambles. From here on, the country was wild. This was disputed territory, owned by now-extinct families, its provenance tied up in generations-old court cases that would probably drag on until the end of the world. Most of the disputed lands were due to the railway allotments created by the preservationists; they had needed clearances that ran completely around the world, and they had gotten them, for a price of blood. This section of land had been abandoned for other reasons, though what they were Garth didn't know. He didn't care, either, as long as the square tower he called home was left in peace.

His intention was to reach it so that he could warn the lady Fanning that they had company—but halfway across the open grassland he heard thuds behind him as half a dozen bodies hit the ground on his side of the wall. They were catching up, and quickly.

He flattened and rolled to one side. Grass swished as dark figures passed by, only feet away. Garth cursed under his breath, wishing there were some way to warn Venera Fanning that six heavily-armed men were about to pay her a visit.

Venera heard them coming. The darkness wasn't total—Diamandis had left a candle burning—so she wasn't completely disoriented when she awoke to voices saying, "Circle around the other side," and "this must be his bolt-hole." A flush of adrenalin brought her completely awake as she heard scratching and scuffling just outside the hovel's door.

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She rolled out of bed, heedless of the pain, and ran to the table where she snatched up a knife. "Down here!" someone shouted.

Where were her clothes? Her jacket lay draped across a chair, and on the table were the bracelet and earrings Diamandis had left her. She cast about for her other things, but Diamandis had apparently moved them. There they were, on another table—next to the opening door.

Venera's first inclination would normally be to draw herself up to her full five foot seven and stare these men down when they entered. They were servants, after all, even if they were armed. If she could speak and make eye contact, Venera was completely confident in her ability to control members of the lower classes.

At least, she used to be. Recent events—particularly her unwelcome dalliance with captain Dentius of the winter pirates—had made her more cautious. In addition, she was sore all over and had a pounding headache.

So Venera snatched up the candle, her jacket, and the jewelry and knelt under the table. The rope ring scraped her raw skin as she yanked on it; after a few tugs the mysterious hatch lifted. She felt down with her foot, making contact with a metal step. As men blundered into Diamandis's home, she billowed the damp sheet behind her, with luck to drape over the hatch and hide it.

The candle guttered and nearly went out. Venera cupped a hand around it and cautiously felt for the next step. She counted seven before finding herself standing in an icy draft on metal flooring. A constant low roar made it hard to hear what was going on above.

This small chamber was oval, wider at the ceiling than at the floor, and ringed with windows. All the panes were flush with the wall, but a couple vibrated at a high speed, making a low braying sound. They seemed to be sucking air out of the room; it was the walls that soaked cold into the place.

Diamandis evidently used the room for storage because there were boxes piled everywhere. Venera was able to make her way among them to the far end, where a metal chair was bolted to the floor. The windows here were impressive: floor-to-ceiling, made of some resilient material she had never seen before.

The candlelight seemed to show a dense weave of leaves on the other side of the glass.

She was going to freeze unless she found something to wear. Venera ransacked the boxes, alternately cursing and puffing out her cheeks in wonder at the strange horde of broken clocks, worn-out shoes, rusted hinges, frayed quills, moldy sewing kits, left socks, and buckles. One crate contained nothing but the dust jackets of books, all their pages having been systematically ripped out. It was a small library's worth of intriguing but useless titles. Another was full of decaying military apparel, including holsters and scabbards, all of it bearing the same coat of arms.

At least the activity was keeping her warm, she reasoned. The faint clomp of boots above continued, so she moved on to a new stack of boxes. This time she was rewarded when she found it packed with clothing. After dumping most of that onto the floor she discovered a pair of stiff leather pants, too small for Diamandis but sufficient for her. Getting into them wasn't easy, though—the material scoured her already-raw skin so that it hurt to move. The leather cut out the wind, however.

Once she had done up the flight jacket, Venera sat down in the metal chair to wait for whatever happened next. This was much harder; it wasn't in Venera's nature to remain still. Staying still made you think, and thinking led to feeling, which was seldom good.

She drew her knees up and wrapped her arms around her shins. It came to her that if they took away Diamandis

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and she couldn't get out of here, she would die and no one would ever know what had happened to her. Few would care, either, and some would rejoice. Venera knew she wasn't well liked.

More stomping up above. She shivered. How far away was her home in Slipstream? Three thousand miles? Four? An ocean of air separated her from her husband, and in that ocean gyred the nations of enemies, rising, lowering, drifting with the unpredictable airs of Virga. Awaiting her out there were the freezing abysses of winter, full of feathered sharks and pirates. Before the sun of suns had roasted her into unconsciousness, she had been determined and sure of her own ability to cross those daunting distances alone. She had leaped from the cargo nets of Hayden Griffin's jet and soared for a time like a solitary eagle in the skies of Virga. But the sun had caught up to her and now she was here, trapped and in pain hardly any distance from where she'd started.

She climbed off the chair, fighting a wave of nausea. Better to surrender herself to whoever waited above than die here alone, she thought—and she almost ran up the steps and surrendered. It was a pulse of pain through her jaw that stopped her. Venera drew her fingertips across the scar that adorned her chin, and then she backed away from the steps.

Her heel caught the edge of a box she'd dropped, and she stumbled back against the icy windows. Cursing, she straightened up, but as she did she noticed a gleam of light welling up through the glass. She put her cheek to it—which dampened the pain a bit—and squinted.

The windows were covered with a long-leafed form of ivy. The stuff was vibrating with uncanny speed—so quickly that the leaves' edges were blurred. Diamandis had said that Spyre rotated very fast; was she looking into the air outside?

Of course. This oval chamber stuck out of the bottom of the world. It was an aerodynamic blister on the outside of the rotating cylinder, and that chair might have once fronted the controls of a heavy machine gun or artillery piece mounted outside. It still might. Frowning, Venera clambered over the mounds of junk back to the metal seat and examined it.

There was indeed a set of handles and levers below the chair, and more between the windows. She didn't touch them but peered out through the glass there, as light continued to well through the close-set leaves.

Candesce was waking up. The sun of suns lit a zone hundreds of miles in diameter here at the center of Virga. Past the trembling leaves, Venera could see a carousel of mauve and peach-painted cloud tumbling past with disorienting speed; but she could also see more.

The oval blister was mounted into a ceiling of riveted metal, as she'd expected. That ceiling was the hull of Spyre. Covering this surface in long runnels and triangles was the strange ivy. Its leaves were like knives, sharp and long, and they all aligned in the flow of the wind. Venera had heard of something called "speed ivy"; maybe that's what this was.

The ivy seemed to prefer growing on things that projected into the airstream. Sheets of metal skin were missing here and there—in fact, there were outright holes everywhere—and the ivy clustered on the leading and trailing edges of these, smoothing the airflow in those places. Maybe that was what it was for.

This view of Spyre was not reassuring. The place was showing its age—dangling sheets of titanium whirred in the wind and huge I-beams thrust down into the dawn-tinted air, whole sagging acres just waiting to peel off the bottom of the world. It was amazing that the place kept itself together.

Next to the blister, a rusted machine gun was mounted on the surface. It faced stoically into the wind, and didn't

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move when Venera tried the controls in front of the chair.

Well. All this was interesting, but not too interesting. She headed back to the stairs, but the light coming through the ranked leaves was considerable now, and she could see more of the blister's interior. So the little passage that opened out behind the stairs was now obvious.

Venera gnawed her lip and rolled her eyes to look at the closed hatch overhead. One hand was on her hip; even here, with no audience, she posed as she thought.

She needed shoes, but she'd recovered the important items, the key to Candesce and her bullet. Venera was quite aware that she was obsessed with that bullet, and who wouldn't be, she usually reasoned, if one like it had flown a thousand miles or more across Virga to randomly spike through a window and into their jaw? This particular projectile had been fired in some distant war or hunting party and missed its target; since there was no gravity nor solid ground to stop it, the thing had kept going and going until it met her. From that encounter Venera had gained a scar, regular crippling headaches, and something to blame for her own meanness. She'd kept the bullet and over time had become consumed with the need to know where it had come from. It was not, she would admit, a healthy need.

She patted the jacket, feeling the heavy shape inside it; then she slipped past the steps and into the narrow passage, and left Diamandis and his invaders to their own little drama.

It was more of a crawlway than a corridor. Venera walked bent over, gasping as the old leather chafed her hips and knees. Why didn't these people dress sensibly? Lit only by intermittent portholes, the passage wormed its way a hundred yards or so before ending in a round metal door. It was all so obviously abandoned—stinking of rust and inorganic decay—that Venera didn't bother knocking on the door, but turned the little wheel in the middle of it and pushed.

She stepped down into a mirror image of the blister she had just left. She half expected to find another maze of boxes on the other side of the steps, with another junk-framed hovel and another Garth Diamandis waiting for her above. But no, the blister was empty save for a half foot of stagnant water and a truly revolting gallery of fungus and cobwebs. The windows were hazed over but provided enough light for a tiny forest that was trying to conquer the metal chair at the far end. The stairs were jammed with soil and roots.

The prospect of dipping her bare feet into that horrid water nearly made her turn back. What stopped her was a tiny chink of light visible in the midst of the soil plug. After wading cautiously and with revulsion through the stinking stuff, she reached up and pulled at the roots. Gradually, in little showers of dirt, worms, and fibrous tubers, she widened a hole big enough for her to shimmy through. A minute later she dragged herself up out and into the middle of a grassy field.

Too bad about Diamandis, but with luck he was still off on his errand and the interlopers wouldn't be there when he got back. Anyway, he'd been more than compensated for taking care of her; that had been a pilot's ransom of gems and faience he'd taken from her jacket. She half hoped those loud burglars found the stuff—it would serve him right.

Venera's own destination was clear. Spyre being a cylinder, it had ends, and one of those was only half a mile away. There the artificial land curved up hundreds of feet in a gesture that would close off the end if continued. The curve ended in a broad gallery above and beyond which the winds of Virga shuddered. She had only to make it up that slope and hop off the edge and Venera would be in free flight again. She would take her chances with the piran-

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hawks and snipers. She doubted any of them could hit one small woman leaving Spyre at four hundred miles per hour.

In this case, wearing leather would serve her well.

Between Venera and the edge of the world lay a chessboard of estates. Each had its tottering stone walls, high hedges, towers, and moats to defend its two or three acres from the ravages of greedy neighbors. Constrained by space and what Venera sensed was deep paranoia, the estates had evolved into similar designs—the larger ones walled, with groves surrounding open fields and a jumble of towers, annexes, and greenhouses at the center; small ones often just a single square building that took up the entire demesne. These edifices were utterly windowless on the outside, but higher up the curve of the world she could see that most contained courtyards crammed with trees, fountains, and statuary.

The walls of some estates were separated by no more than twenty feet of no-man's land. She ran through these weed-choked alleys, dodging young trees, past iron-faced pillbox gates that faced one another across the minor space like boxy suits of armor. The footing was treacherous, and she suspected traps.

Venera was used to higher gravity than Spyre's. Tired and sore though she was, it was easy for her to leap ten feet to the top of a stone wall and run its length before dropping to the grass beyond. Her feet barely felt brick, root, and stone as she wove in and out of the trees, sprinted around open ponds under windows that were just beginning to gleam yellow in the light of Candesce. As she ran she marveled that such distances could exist; she had never run so far in a straight line and could hardly believe it possible.

The birds were the only ones making sound, but as she ran Venera began to notice a deep rushing roar that came from ahead of her. It was the sound of the edge of the world, and with it there came the beginnings of a breeze.

She heard surprised shouts as she crossed one fanatically perfect lawn, bare feet kissing wet grass. Glancing to the side, Venera caught a glimpse of a small party of men and women sitting on curlicued iron chairs in the morning light. They were sipping tea or something similar.

They stood up—stiff ornamented garments ratcheting into their standing configurations like portcullises slamming down—and the three men howled "intruders!" as if Venera were an entire army of pirates. After a moment, sirens sounded inside the looming stone pile behind them.

"Oh, come *on!*" She was panting with exhaustion now, her head swimming. But there were only two more estates to pass, and then she would be on the slope to the world's edge. With a burst of speed she raced by more lighting windows and opening doors, noting abstractly that the considerable mob of soldiers who had spilled out of the first place's doors had stopped at the edge of their property as if they'd slammed into an invisible fence.

So she only had to outrace the alarm in each particular property. It could be a game, and Venera actually would have enjoyed the chase if she hadn't been on the verge of fainting from exhaustion and residual heatstroke. If only she had the breath to taunt the idiots on the way by!

Gunshots cut the air as she passed the last estate. This was one of the big single-building affairs, all gray asteroidal stone drizzled with veins of bright metal. Its only external windows were murder slits that started fifteen feet up, and she saw no doors. Empty upward-curving fields beckoned on the other side of the edifice; she staggered onto what Diamandis had called 'disputed territory' and paused to catch her breath. "Ha! Safe!"

The wind was now a harsh constant moan, flickering past her in gusts. It

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spun in little permanent tornadoes over gaps and holes in Spyre's skin. There were more and more such holes as the slope rose to the edge. The edge itself was ragged, a crenellation of collapsed galleries, up-thrusting spars and flapping plates that added to the din.

She heard something else, too. A regular creaking sound seemed to be coming from overhead. Venera looked up.

Six wooden platforms had been lowered over the top of the stone cube and were being winched down. Each was crowded with men in tall steel helmets and outlandish spiked armor. They clutched pikes and rifles with barrels longer than they were tall. Several were pointing at her excitedly.

Venera swore and took off up the rubble-strewn slope. The wind was at her back, and it became stronger the closer she got to the edge. Several gusts lifted her off her feet. Venera noticed that the metal skin of Spyre was completely exposed in the final yards leading up to the edge. Only fair-sized rocks inhabited the area behind it. As she watched, a stone the size of her foot rolled up the metal and spun off into the air. A few more yards and the wind would take her, too.

Her foot sank into the slope and Venera fell in ridiculous slow-motion. As she pried herself upright again she saw that the metal plate bent by her foot was vibrating madly in the square hole it had made. Then with a loud pop it disappeared and suddenly a hurricane was howling into the bright aperture it had left.

Venera was sucked down and slid forward until she was right over the hole. She reached out and braced her hands on either side while the air screamed past her. It was trying to escape Spyre with even more passion than hers. For a few seconds she could only stare down and see what faced her if she made it to the edge and jumped.

Many long flagpole-like beams thrust out below the edge of the world. They trailed wire nets into the furious wind; anyone caught on those nets would suffocate before they could be pulled up. Far beneath the nets, where scudding clouds spun past, Venera glimpsed thousands of black specks and grayish veins in the air. Mines? More razor wire? Diamandis had not been lying, after all.

"Damn! Shit!" She tried to scream more curses—every one she could think of—but the air was being pulled out of her lungs. She was about to faint into the hole and die.

Strong hands took her by the arms and legs and hauled her back. Venera was hoisted onto someone's back and unceremoniously toted back down the slope. With every jolting step escape, and home, and Chaison receded past the frame of her grasping fingers.

3

Although he was her favorite uncle, Venera never saw much of Prince Albard. He was a mysterious figure on the periphery of the court, sweeping into Hale in his yacht to regale her with tales of strange cities and the outlandish women he'd met there (always sighing when he talked of them). His face was split down the center by a saber scar, putting his lips into a permanent twist that made it look like he was smirking. Unlike most of the people who encountered him, Venera knew that he *was* smirking—laughing inside at all the pointless desperation and petty recrimination of life. In that regard he was the polar opposite of her father, a man with a mind focused by a single lens of suspicion; maybe that was why she clung to Albard's knees when he did appear, and treasured the odd-shaped dolls and toys he brought.

They recognized each other, this vagabond prince in his motley and the pouting princess in clothes she systematically tattered as soon as she was in them. So maybe it was natural that when the time came, it was in her bedroom that Albard barricaded himself.

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He only noticed her after he had dragged her wardrobe across the door and piled some chairs and tables around it. "Damn, girl, what are you doing here?"

Venera had cocked her head and squinted at him. "This is my room."

"I know it's your room, dammit. Shouldn't you be at lessons?"

"I bit the tutor." Banished and bored, she had (not out of anger but a more scientific impulse) been beheading some of her dolls when Albard swept in. Venera had assumed that he was there to talk to her and had politely waited, limp headless body in one hand, while he proceeded to move all the furniture. So he wasn't there to see her? What, then, was this all about?

"Oh, never mind," he said irritably, "just stay out of sight. This could get ugly."

Now she could hear shouting outside, sounds of people running. "What did *you* do?" she asked.

He was leaning back against the pile of furniture as though trying to propel it out the room. "I bit someone, too," he said. "Or, rather, I was about to, and they found out."

Venera came and sat down on the fuchsia carpet near him. "My father, right?"

His eyebrows rose comically. "How did you guess?"

Venera thought about this for a while. Then she said, "Does that mean that everybody who makes Father mad has to come to this room?"

Albard laughed. "Niece, if that were true, the whole damn kingdom would be in here with us."

"Oh." She was slightly reassured.

"Give it up, Albard!" someone shouted from outside. It sounded like her father. There was some sort of mumbling discussion, then: "Is, uh . . . is Venera in there with you?"

"No!" The prince put a finger to his lips and knelt next to her. "The one thing I absolutely will not do," he said gently, "is use you as a bargaining chip. If you want to leave, I will tear down this barricade and let you go."

"What will they do to you?"

"Put me in chains, take me away . . . then it all depends on your father's mood. There's a black cloud behind his eyes lately, have you seen it?" She nodded vigorously. "It's getting bigger and bigger, that cloud, and I think it's starting to crowd out everything else. That worries me."

"I know what you mean."

"I daresay you do." There followed a long interval during which Albard negotiated with the people on the other side of the furniture. Venera retreated to the window, but she was far from bored now. At last Albard blew out his cheeks and turned to her.

"Things are not going well," he said. "Do you have a pen and some writing material?" She pointed to the desk that perched on top of the barricade. "Ah. Much obliged."

He clambered up and retrieved a pen and some paper. Then, frowning, he dropped the paper. He went to his knees and began hunting around for something, while Venera watched closely. He came up with one of her dolls, a favorite that had a porcelain head and cloth body.

"Do you mind if I borrow this for a minute?" he asked her. She shrugged.

Albard rubbed the doll's face against the stone floor for a while, while crashing sounds started from the hallway. The barricade shook. Holding the doll up critically, the prince grunted in satisfaction. Then he hunched over and began delicately pressing the pen against its face.

He was standing in the center of the room with his hands behind his back when the barricade finally fell. A dozen solders came in, and they marched him out; he only had time to look back and wink at Venera before he was gone.

After they'd taken him away, some members of the secret police ransacked

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her room. (That it looked substantially the same when they left as before Albard had arrived was a testament to her own habits.) They seized everything that could write or be written on, even prying the plaster off the wall where she'd scribbled on it. Venera herself was frisked several times, and then they swirled out, all clinking metal and bandoliers, leaving her sitting in the exact spot where he had been standing.

Neither she, nor anyone she would later meet, ever saw Albard again.

Eventually, she moved over to the window and picked up a particular doll. Its tunic was ripped where the secret policemen had cut it open looking for hidden notes. Venera held it up to the window and frowned.

So that was what he'd been doing. Albard had rubbed its eyebrows off against the stone. Then, in meticulous tiny lines and curls, he had repainted them. From a distance of more than a few inches they seemed normal. Up close, though, she could see what they were made of:

Letters.

The nation of Liris curled around its interior courtyard as though doubled up in pain. Every window stared down at that courtyard. Every balcony overhung it. The bottom of this well would be in permanent shadow if not for the giant mirrors mounted on the roof, which were aimed at Candesce.

Venera could plainly see that the courtyard was the focus of everything—but she couldn't see what was down there. For the first two days of her stay she was shuttled from small room to small room, all of them lined up in a short hallway painted institution green. After a brief interview in each chamber she was taken back to a drab waiting room, where she sat and ate and slept fitfully on the benches. She was startled awake every morning by a single gunshot sounding somewhere nearby. Morning executions?

It seemed unlikely; she was the sole inhabitant of this little prison. Prison it clearly was. She had to fill out forms just to use the one washroom, a cold cube with wooden stalls defaced by centuries of carven graffiti. Its high, grated windows gave her a view of the upper stories of the inner courtyard. They hinted at freedom.

"B-b-back to waking?" Venera sat up warily on the third morning and tried to smile at her jailor.

He was tall, athletically muscled, and possessed the sort of chiseled good looks one saw in actors, career diplomats, or con artists. As dapper as could be expected for a man dressed in iron and creaking leather, he might have melted any lady's heart—provided she never looked in his eyes or heard him speak. Either of those maneuvers would have revealed the awful truth about Moss: his mind was damaged somehow. He seemed more marionette than man and, sadly, appeared to be painfully aware of his deficit.

Just as he had yesterday, Moss carried a stack of forms in one hand, bearing it as though it were a silver platter. Venera sighed when she saw this. "How long is it going to take to process me into your prison?" she asked as he clattered to a stop in front of her.

"P-p-prison?" Moss gaped at her. Carefully, as though they were gold, he placed the papers on the peeling bench. His metal clothing gnashed quietly as he straightened up. "You're n-not in p-p-prison, my lady."

"Then what is this place?" She gestured around at the sound-deadening plaster walls, the smoke-stained light sconces and battered benches. "Why am I here? When do I get my things back?" They'd gone through her jacket and taken its contents—jewelry, key, and bullet. She wasn't sure which loss worried her most.

Moss's face never changed expression as he spoke, but his eyes radiated some sort of desperate plea. They always did, even if he was staring at the wall. Those

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eyes seemed eloquent, but Venera was beginning to think that nothing about Moss's looks or demeanor meant anything about his inner state. Now he said, in his intensely flat way, "This is the im-immigration department of the g-g-government of Liris. You were brought here to t-t-take your citizenship-ip exams."

"Citizenship?" But now it all made sense—the forms, the sense of being processed, and the succession of minor officials who'd taken up hours of her time over the past days. They had grilled her mercilessly, but not about how or why she had come here, or about what her plans or allegiances might be. They didn't even want to know about her peeling sunburns. No, they'd wanted to know the medical histories of her extended family, whether there was madness in her line (a question that had made her laugh), and what was the incidence of criminality among her relatives.

"Well, my father stole a country once," she had answered. She had of course asked them to let her go, in perhaps a dozen different ways. Her assumption was that she would be ransomed or otherwise used as a bargaining chip. With this in mind, she had sat anxiously for hours, wondering about her value to this or that state or person. It had never occurred to Venera that she might be adopted by Liris as one of its own.

Now as she realized what was going on, Venera had one of the strangest moments of her life. She felt, for just a second, relief at the prospect of spending the rest of her life hidden away here, like a jewel in a safe. She shook herself, and the moment passed. Disturbed, she stood and turned away from Moss.

"B-b-but the news is good," said Moss, who looked like he was begging for death as he said it. "D-don't fret. You have p-p-passed all the t-t-tests so far. J-just one set of forms to g-go."

Venera gnawed at her knuckle, each bite sending little pulses of pain up her jaw. "What if I don't want to be a citizen of Liris?"

Moss proceeded to laugh, and Venera swore to herself she would do anything to avoid seeing *that* again. "F-Fill these out," he said. "A-and you're done."

It wasn't eagerness to become a citizen of a nation the size of a garden that made her sign the papers. Venera just wanted to get her things back—and get out of the waiting room. What she'd felt a moment ago was just a craving for anonymity, she told herself. Citizenship of any nation meant nothing to her, except as a sign of lowly status. Her father was hardly a citizen of Hale, after all; he *was* Hale, and other people were citizens of him. Venera had grown up believing she, too, was above such categories.

"Come," was all Moss said when she was finished. He led her out into the hallway, and at its end, he unlocked the great metal door with its wire-mesh window. Before pushing the portal open, he picked up an open-topped box and held it out to her.

Inside were the necklace and earrings he'd confiscated from her jacket when she arrived. Rolling next to them was her bullet.

The key to Candesce was not there.

Venera frowned but decided not to press the matter just now. Moss gestured with one hand and she edged past him into her new country.

Shafts of dusty sunlight silhouetted tall stone pillars. Their arched capitals were muted in shadow, but the polished floors gleamed like mirrors. Save for a wall where the edge of the courtyard should be, the whole bottom floor of the great cubic building seemed open. Filling the space were dozens and dozens of cubicles, desks, worktables, and stalls.

Indeed, it seemed as if all the roles of a midsized town were duplicated here—tailor over here, doctor there, carpenters on this side, bricklayers on that—but all gathered in one room.

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Bolts of cloth were stacked with bags of cement. Drying racks and looms had been folded up under the ceiling to make way for chopping blocks and flour-covered counters. And working in determined silence throughout this shadow-cut space was a small army of silent, focused people.

Each was isolated at some chair or desk, and Venera had the startled impression that these work stations had grown up and around some of the people, like shells secreted around water creatures. It must have taken years for that man there to build the small ziggurat of green bottles that reared above his desk; nearby a woman had buried herself in a miniature jungle of ferns. Mirrors on stands and hanging from strings cunningly directed every stray beam of light within ten feet at her green fronds. Each position had its eruption of individuality or downright eccentricity, but their limits were strictly kept; nobody's keepsakes and oddities spilled beyond an invisible line about five feet in radius.

Moss led her to an outer wall, where he opened a dim chamber that reminded her of Diamandis's warren. Here were crates and boxes full of what looked like armor—except she knew it for what it was. "You are required to wear four hundred and fifty p-p-pounds of mass during the day," said Moss. "That will offset our r-reduced g-gravity and maintain the health of your bones." He stood back, arms crossed, while Venera rooted through the mess looking for something suitable.

It seemed that Spyre's tailors were an unimaginative lot. The room contained an abundance of blouses, dresses and skirts, pants and jackets, but all were done in intricately tooled and hinged metal. Only undergarments—those directly in contact with the skin—were made of suppler materials, mostly leather, though to her relief she did find some cloth. Venera tried on a vest made of verdigrised copper scales, added a skirt made of overlapping iron plates and weighed herself. Barely one hundred pounds. She went back and found greaves and wrist bracers, a platinum torque, and a steel jacket with tails. Better, but still too light. Moss waited patiently while she layered herself like a battleship. Finally when she topped the scales at one hundred pounds weight—five hundred pounds mass—he grunted in satisfaction. "B-but you need a h-h-hat," he said.

"What?" She glared at him. He had something like a belaying pin tied to his head; it wobbled when he moved. "Isn't all this humiliating enough?"

"We m-must put p-p-pressure on the s-spine. For l-long-term health."

"Oh, all right." She hunted through a cache of ridiculous alternatives, ranging from flowerpots with chinstraps to a glass fish bowl, currently empty but encrusted with rime. Finally she settled on the least offensive piece, a chrome helmet with earflaps and crow's wings mounted behind the temples.

With all of this on her, Venera's feet made a satisfactory smack when they hit the ground. She could feel the weight and it was indeed nearly normal, but spread all over her surface instead of internally. And she quickly discovered that it took a good hard push to start walking and that turning and stopping were not operations to be taken lightly. She had a quarter-ton of inertia now. After walking into several walls and doorjambs, she started to get the hang of it.

"N-now," said Moss in evident satisfaction, "you are f-fit to see the B-B-Botanist."

"The what?" He threaded his way among the pillars without further comment. Venera nodded and smiled at the men and women who were putting down their work to openly stare as she passed. She tried to unobtrusively discern what they were working on, but the light here was too uneven. Shadow and glare thwarted her.

Sunlight reflecting off the polished floor washed out whatever was ahead.

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Venera glanced back one more time before entering the lit area. Blackness and curving arches framed a dozen white ovals—faces—all turned toward her. On those faces she read every emotion: amazement, curiosity, anger, fear. None avoided her gaze. They goggled at her as though they'd never seen a stranger before.

Maybe they hadn't: Venera's scalp prickled, but Moss was waving her ahead. Blinking, she stepped from the dark gallery into the courtyard of Liris.

For a moment it seemed as if she'd entered one of the paintings on the ceiling of her father's chapel. This one came complete with scented pink clouds. She reached out a hand to touch one of these and heard the sharp click of a weapon being cocked. Venera froze.

"It would be very unwise of you to complete that gesture," drawled a voice from somewhere ahead. Slowly, Venera retracted her hand. As her eyes adjusted to the brightness, she saw the barrels of three antique-looking rifles aimed her way. Grim men in iron held them.

The soldiers made a shocking contrast to their setting. The entire courtyard was full of trees, all of one type, all in full flower. The scent and color of the millions of blossoms was overwhelming. It took Venera a moment to notice that the branches of many of the trees were hung with jewels, and gold rings encircled some of the trunks. It took her another moment to realize that a throne sat in the sole bare patch at the center of the courtyard. The woman lounging there was watching her with obvious amusement.

Her gown was of gold, silver, and platinum; on her head was a crown touched with gems of all shades that flashed in the concentrated light of Candesce. She appeared to be in early middle age, but was still beautiful; a cascade of hair dyed the same color as the blossoms wound down her shoulders.

"You seem reluctant to step into sunlight," she said with evident amusement. "I can see why." She tapped her own cheeks, eyes twinkling.

Venera eyed the soldiers, thought about it, and walked over. Since this was evidently a throne room of sorts, she bowed deeply. "Your . . . majesty?"

"Oh. Oh no." The woman chuckled. "I am no queen." She waved a hand dismissively. "We are a meritocracy in Liris. You'll learn. My name is Margit, and I am Liris's resident botanist."

"Botanist . . ." Venera straightened and looked around at the trees. "This is your crop."

"Please." The lady Margit frowned. "We don't refer to the treasure of Liris in such prosaic terms. These beings *are* Liris. They sustain us, they give us meaning. They are our soul."

"Pardon, m'lady," said Venera with another bow. "But . . . what exactly *are* they?"

"Of course." Margit's eyes grew wide. "You would never have seen one before. You are so lucky to gaze upon them for the first time when they are in flower. These, Citizen Fanning, are *cherry* trees."

Why was that word so familiar? There'd been a ball once, and her beloved uncle had approached her with something in his hand . . . a treat.

"What are cherries?" she asked as guilelessly as she could.

"An indulgence of the powerful," said Margit with a smile. "A delicacy so rare that it evidently never made it to your father's court."

"About that," said Venera. "The court, I mean. My family is fantastically rich. Why make me a . . . citizen of this place, when you could just ransom me back? You could get a boatload of treasure for me."

Margit scoffed. "If you were the princess of a true nation then perhaps we would consider it. But you're not even from the principalities! By your own admission during the interviews, you come from the windswept wastes of Outer Virga. There's nothing there,

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and I find it hard to believe your people could own anything that would be of interest to us."

Venera narrowed her eyes. "Not even a fleet of battle cruisers capable of reducing this place to kindling from twenty miles away?"

Not only Margit laughed at this; the soldiers did as well. "Nobody threatens Spyre, young lady. We're impregnable." Margit said this so smugly that Venera swore she would find a way to throw her words back at her.

Margit snapped her fingers, and Moss stepped forward. "Acquaint her with her new duties," said the botanist.

Moss stared at her, slack jawed. "W-what are those?"

"She knows the languages and cultures of other places. She'll be an interpreter for the trade delegation. Go introduce her." Margit turned away, lifting her chin with her eyes closed so that a beam of sunlight flooded her face.

On her seventeenth birthday, Venera snuck out of the palace for the first time, acquired the means to blackmail her father, killed her first person, and met the man she was destined to marry. She would later tell people that "it all just sort of happened."

The capital of Hale was a collection of six town-wheels—spinning rings, each two thousand feet in diameter—surrounded by an ever-shifting cloud of weightless buildings and smaller rings. The main sound in the city was the rumbling of jet engines, as various rings and large municipal structures struggled to keep their spin and to avoid colliding. The scent of kerosene hung in the air; underlying it were other industrial and biological odors, just as under the rumbling of the engines you could hear shouts, horns, and the laughter of dolphins.

Venera had grown up watching the city life from afar. When she traveled between the town-wheels it was usually in a closed taxi. Sometimes one or another of the nobility hosted weightless balls; then she and the other ingenues donned fabulous wings that were powered by stirrups, and flew intricate dances in the warm evening air. But that flight always took place within careful limits. Nobody strayed.

She was of marriageable age now—and had recently come to realize that in Hale, marriageable also meant murderable. Venera had three sisters and had once had three brothers. Now she had two of those, and the once-close girls of the family were starting to actively plot against one another. With the boys, it was all about succession; with the girls, marriage.

Someone had used a marvelous word at a dinner party just a few days before: *leverage*. Leverage was what she needed, Venera had decided. And so her thoughts had turned to old family tragedies, and the mysteries that had consumed her as a girl.

Today she was dressed in the brown blouse and pantaloons of a servant-girl, and the wings on her back were not butterfly orange or feathered pink, but beige canvas. Her hair was tied down with a drab cloth, and she soared the air of the city barefoot. In her waist bag she carried some money, a pistol, and a porcelain-headed doll. She knew where she was going.

The bad neighborhoods started remarkably close to the palace. This fact might have had something to do with the royal habit of simply dumping waste off the palace-wheel without regard to trajectory or velocity. The upper classes couldn't be entirely blamed for the stench that wafted at Venera as she flapped toward her destination, however. She wasn't disgusted; on the contrary, the smell and the sound of arguing, shouting people made her heart pound with excitement. Since she was little she'd sat for hours with her eye glued to a telescope, watching these citizens and this neighborhood roll by as the palace turned past it. She knew the

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place—she had simply never been here.

What Venera approached looked like nothing so much as an explosion frozen in time. Even the smoke (of which there was plenty) was motionless or rather, it moved only as quickly as the air that oozed slowly between the hundreds of cubes, balls, and disheveled shapes that counted as buildings here. Anything not tied down hung in the air and drifted gradually, and that meant trash, animal hair, balls of dirty water, splinters, and scraps of cloth all contributed to the cloud. When the doldrums of summer broke and a stiff wind finally did snake through the place, half the mass of the neighborhood was going to simply blow away, like chaff. For now it roiled around Venera as she ducked and dove toward the gray blockhouse that was her destination.

Her business in the building was brief, but every detail of the transaction seemed etched in extraordinary detail—for here were people who didn't know who she was. It was marvelous to be treated as servants and ordinary folk treated one another, for a change—marvelous and eye opening. Nobody opened the door to the place for her; she had to do it herself. Nobody announced her presence, she had to clear her throat and ask the man behind the counter to help her. And she had to *pay*, with her own money!

"The contents of locker six sixty-four," she said, holding out the sheet of paper she'd written the information on. The paper was for his benefit, not hers, for she'd memorized the brief string of letters and numbers years ago. Deciphering the letters Uncle Albard had penned on her doll's forehead had been one of her primary motivations to learn to read.

The keeper of the storage lockers merely grunted and said, "Get 'em yourself. If you've got the combination, you get in, that's the rule." He pointed to a doorway at the end of the counter.

She made to go that way, and he said, "Back pay's owing on that one. Six hundred." He grinned like a shark. "We were about to clear it out."

Venera opened her bag, letting him see the pistol as she rummaged for the cash. He took it without comment and waved her through the door.

The only thing in the dingy locker was a water-stained file folder. As she stood in the half light, flipping through it, Venera decided it was all she needed. The documents were from the College of Succession at the University of Candesce, two thousand miles away. They included DNA analyses that proved her father was not of the royal line.

She barely saw the tumbled buildings as she left the blockhouse; maybe that's why she got turned around. But suddenly Venera snapped to attention and realized she was in a narrow chute formed by five clapboard structures, on her way down, not up toward the palace. Frowning, she grabbed a handy rope to steady herself and turned to go back the way she'd come.

"Don't." The voice was quiet, and came from above and to the left. Venera flipped over to orient herself to the speaker. In the gray reflected light from shingle and tar paper, she saw a youth—perhaps no older than herself—with tangled red hair and the long bones of someone raised in too little gravity. He smiled toothily at her and said, "Bad men coming behind you. Keep going and take your first hard right, and you'll be safe."

She hesitated, and he scowled. "Not shittin' ya. Get going if you know what's good for you."

Venera flipped again, planted her feet on the rope, and kicked off down the chute. As she reached the corner the boy had indicated, she heard voices coming from the far end of the chute—opposite the way he'd said the bad men were coming from.

This side way led quickly to well-traveled airspace and had no niches or doors out of which someone could

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spring. Feeling momentarily safe, Venera peeked around the corner of the chute. Three men were flying slowly up from the left.

"I really think you've gotten us lost this time," said the one in the lead. He was in his late twenties and obviously noble or rich from his dress and demeanor. One of his companions was similarly dressed, but the third man looked like a commoner. She couldn't see much more in the dim light. "The palace is definitely not this way," continued the leader. "My appointment is at two o'clock, I can't afford to be late."

Two o'clock? She remembered one of the courtiers telling her that an admiral from some neighboring country would be calling on her father in the early afternoon. Was this the man?

Suddenly one of the other men shouted, "Hey!" He had barely writhed out of the way of a sword that had suddenly appeared in the third one's hand. "Chaison, it's a trap!"

Four men shot down the chute from the right. They were rough-looking, the sort of thug Venera had watched roaming the neighborhood through her spyglass and sometimes fantasized about. All had drawn swords and none spoke as they set upon their two victims.

The one named Chaison whirled his cloak into the air between himself and the attackers and drew his sword as his friend parried a thrust from their erstwhile guide. After the initial warning from Chaison's friend, nobody spoke.

In a free-fall swordfight, the blade was as much propulsion as weapon. Each of the men found purchase in wall or rope or opponent with hand, foot, shoulder, or blade as they could. Each impact sent them in a new direction, and they tumbled and spun as they slashed at one another. Venera had watched men practice with swords and had even witnessed duels, but this was totally different. There was nothing mannered about it; the fight was swift and brutal. The men's movements were beautiful, viscerally thrilling and almost too fast to take in.

One of the attackers was hanging back. As his face intersected a shaft of light, she realized it was the boy who had warned her. He held his sword up, wavering, in front of his face and ducked away from the embattled older men.

It took Venera a few seconds to realize that two of the men bouncing from wall to wall were now dead. There were black beads dotting the air—blood—and more was trailing the bodies, which continued to move, but only languidly, from momentum. One was the guide who had brought the two noblemen here; another was one of the attackers.

"Stand down!" Chaison's voice startled Venera so much that she nearly lost her grip on the wall. The remaining three attackers paused, holding onto ropes and bent shingles, and stared at their dead compatriots. The boy looked sick. Then one of his companions roared in anger and jumped.

He spun away, slashed in the face by Chaison's companion. The other man had his sword knocked out of his hand by Chaison, who finished the uppercut motion with a blow to his jaw.

The boy was hanging in midair with his sword held out in front of him. Chaison glimpsed him out of the corner of his eye, spun, and—stopped.

The blade trembled an inch from the boy's nose. He went white as a sheet.

"I'm not going to hurt you," said Chaison. His voice was soft, soothing—in total contrast to the bellow he had given moments ago. "Who sent you here?"

The boy gulped and, seeing that he still held his sword, he let go of it spasmodically. As it drifted away, he said, "B-big man from palace. Red feather in his hat. Didn't give a name."

Chaison made a sour face. "All right. Now off with you. Find another line of work—oh, and some better friends." He reached for his companion's wrist and they locked arms to coordinate their flight. Together they turned to leave.

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The man who'd been struck in the chin suddenly snapped his head up and raised his arm. A snub-nosed pistol gleamed in his grimy fist. The boy gasped as he aimed it point-blank at the back of Chaison's head.

Bang! A spray of blood filled the air and the boy shrieked.

Venera peered through the blue cloud of gunsmoke. Chaison's would-be assassin was twitching in the air, and both noblemen were staring past him, at her.

She returned the pistol to her carrying bag. "I-I saw you were in trouble," she said, surprised at how calm she sounded. "There was no time to warn you."

Chaison glided over. He looked impressed. "Thank you, madam," he said, graciously ducking his head. "I owe you my life."

In her fantasies, Venera always had a perfect comeback line at moments like this. What she actually said was, "Oh, I don't know about that."

He laughed.

Then he extended his hand. "Come. We'll need to explain ourselves to the local police."

Venera flushed and backed away. She couldn't be caught out here—quite apart from the scandal, her father would ask too many questions. The papers she had just recovered might come to his attention, and then she was as good as dead.

"I can't," she said and turning, kicked off from the corner as hard as she could.

She heard him shouting for her to stop, but Venera kept on and didn't look back until she had passed through three crowded markets and slipped down five narrow alleys between soon-to-collide buildings. Cautiously, she worked her way back to the palace and changed in the guardroom while the man she'd bribed to let her out and in again waited nervously outside.

The next time she saw Chaison Fanning it would be two nights later, at a formal ball. He told her much later that his astonishment when he recognized her completely drove out all thoughts of the new treaty with Hale that he was celebrating. Certainly the expression on his face was priceless.

Venera had her own reason to smile, as she had learned who had tried to have this handsome young admiral killed. And as she danced with Chaison Fanning, she mused about what exact words she would use when she confronted her father. She already knew what it was she would be asking him for in exchange for her silence regarding his nonroyal origins.

For the first time in her young life, Venera Fanning began to conceive of an existence for herself away from the intrigue and cruelty of the Court of Hale.

4

A thick cable rose from the roof of the Nation of Liris. Venera squinted at it, then at the blunderbusses the soldiers cradled. Another, larger blunderbuss was mounted on a pivot under a little roof nearby. That must be the damnable gun whose firing kept waking her up in the morning.

None of those ancient arms looked very accurate. She could probably just jump off the roof and run for it . . . but run where? Chances were she'd be snapped up by some neighbor worse than these people.

She decided—for the tenth time today—to remain patient and see what happened. No one in Liris seemed to have any immediate desire to harm her. Her best strategy was to play along with them until the moment came when she could escape.

"Now pay attention," whined Samson Odess. The fish-faced little man had been introduced yesterday as her new boss. The very idea of a commoner giving her orders without an immediate threat to back them up struck Venera as both bizarre and funny. She had so far done the things he had asked, but Odess seemed to sense that she wasn't taking

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him seriously. He was becoming ever more defensive as the morning wore on.

"This is our lifeline to Lesser Spyre," Odess said, slapping the cable. Venera saw that he stood on a low platform, at the center of which was a boxy machine that clamped the cable with big ratchet wheels. "By means of this engine, we can rise to the city above, where the Great Fair is held once a week. Visitors from everywhere in Virga come to the Fair. It is the trade delegation's sacred task to ensure that we conduct the most advantageous transactions in the name of Liris." As he spoke, the rest of the delegation popped up through the roof's one hatch. Four heavily armed men bracketed an iron box that must have held pitted cherries. Flanking them were two men and two women, the women veiled like Venera and dressed in ceremonial robes of highly polished silver, inlaid with crimson enamel.

"Is the gravity the same up there as it is here?" Venera asked. If it was a standard *g*, they wouldn't be able to move.

Odess shook his head vigorously. "You can see the spin-rate from down here. We'll shed our heavy vestments for city clothes once we're up there."

"Why not change down here?" she asked, puzzled.

Odess goggled at her in astonishment. He'd stared exactly that way yesterday, when he was first introduced. Moss had taken Venera to Odess's office, a glorified closet that made her wonder if Diamandis's pack-rat ways might not be the rule here, rather than the exception. Odess had filled the small space over the years, perhaps his whole lifetime, with oddments and souvenirs that likely made sense to no one but him. What was the significance of that single shoe, mounted as though it were a trophy and given its own little niche in the wall? Could anyone read the faded text on those certificates hung behind his chair? And was that some sort of exotic mobile that drooled from the dimness overhead, or the hanging mummified remains of some sort of animal? Books were stacked everywhere, and a pile of dishes three feet tall teetered next to a rolled-up mattress.

Odess's first words were addressed to Moss, not Venera. "You expect us to accept this . . . this *outsider* in our midst?"

"Is th-that not what you d-do?" Moss had asked. "G-go *outside?*" Startled, Venera had sent him a sidelong look. Was there somebody home behind those glazed eyes, after all?

"B-besides, the b-botanist commanded it."

"Oh, God." Odess had put his head in his hands. "She thinks she can do anything now."

Any slight deviation from routine or custom threw Odess into a panic. Venera's very presence was upsetting him, though the rest of the delegation had been pathetically happy to meet her. They would have partied till dawn if she hadn't begged off early, pointing out that she had not yet seen the room where she was expected to sleep for the rest of her life.

Eilen, Mistress of Scales and Measures, had shown Venera to a closet just outside the delegation's long, cabinet-lined office. The closet was seven feet on a side—its walls of whitewashed stone—and nearly twelve feet high. There was room for a bed and a small table, and there was no window. "You can put your chest under the bed," Eilen said, "when you get one. Your clothes you can hang on those pegs for now."

And that was all. If Venera were inclined to sympathy with other people, she would have been saddened at the thought that Eilen, Odess, and the others accepted conditions like these as the norm. After all, they had likely been born and raised in such tiny chambers. Their playgrounds were dusty servants' ways, their schoolrooms window niches. Yet of all the citizens of Liris, they were the privileged ones, for as members of the delegation they were allowed to see something of the world

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outside their walls.

While Odess sputtered and tried to explain why tradition demanded that they rise to Lesser Spyre in full ceremonial gear, Venera watched the soldiers deposit their precious cargo on the platform. After the rest of the delegation was on board, they flipped up railings on all sides (to her relief) and one bent to examine the archaic engine. This was what really interested her.

"If we're all ready, we will sing the Hymn of Ascension," said Odess, portentously.

Venera looked around. "The what?"

He looked as though he'd been slapped—but Eilen put a hand on his arm. "We didn't tell her about it, so how would she know?"

"Anyone in Spyre could see us arise, hear the . . ." He realized his mistake. "Ah yes. A true foreigner." Shaking himself, he put both hands on the rail and puffed out his cheeks. "Listen, then, and learn the ways of a civilized society."

While they sang their little ditty, Venera watched the soldier spark the hulking rotary engine into life. Its chattering roar immediately drowned out the miniature choir, who didn't seem to notice. The wheel turned, gripping the cable, and the platform inched slowly into the air.

The purpose of the railings soon became clear. Only a few yards above the rooftop they caught the edge of the howling gale that swept toward the open end of Spyre. This steady hurricane was produced by the rotation of the great cylinder, Venera knew; she'd seen its like in smaller wheels like those of Rush. A wind came in at the cylinder's axis of rotation and shot out again along the rim. If she simply jumped off the platform at this point, she would be propelled out of Spyre entirely, and at goodly force.

The four soldiers were here to shoot anyone who tried that. And now that they were higher up she could see other guarantors of obedience: gun emplacements were suspended in the middle air by more cables, and some of them were visibly manned. Hanging in the sunny clouds beyond the wheel were more bunkers and turrets. It seemed a miracle now that she had, unconscious, threaded her way between them all to land here.

"Father would love this place," she muttered.

Chaison Fanning, her missing husband, would probably consider Spyre a moral obscenity, and would want to blow it up.

They rose some miles, through filigrees of cloud, puffballs that hovered like anxious angels between the incoming and outblowing gales; past houses and pillboxes bolted to other cables, whose glittering windows revealed nothing of what might be taking place inside them. The lands of Greater Spyre widened and widened below Venera, their patchwork estates becoming a mesmerizing labyrinth: the blockhouses of a dozen, a hundred and more Nations of Liris, it seemed, painted the inside of the cylinder. Slicing through these, leaving ruin and wildflowers on their sidings, were the railways of the preservationists.

All the while, Lesser Spyre came closer.

Venera had seen a geared town once before—in the dead hollow heart of Leaf's Choir, Chaison Fanning's ships had moored next to the asphyxiated city of Carlinth. But Carlinth's pale grandeur couldn't match the wonder of Lesser Spyre because that other city had been motionless in death, and Lesser Spyre lived. Its great wheel-shaped habitats, each a half mile or more in diameter, turned edge to angled edge like the meshwork of a vast clock. The citizen of one wheel could stroll to its edge and simply step onto the surface of another as their rims came within touching distance. The wheels were kept in configuration by a lattice of giant spars and thick cables, from which black banners fluttered.

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For all this cunning and motion, Lesser Spyre did not look inviting. There were some houses and streeets, but most of the wheels were dominated on their inside surface by one or two sprawling buildings. The Admiralty at Rush had been like that, as had the Pilot's palace. But also in Rush there were wheels weeded with taverns, towers, and twisting streets, as organic and inviting as a party.

Lesser Spyre was monolithic, self-contained, and controlled. Almost nothing stuck out.

The cable car eluded gravity entirely after a while, and its passengers clipped their metal costumes to the railing and waited until their destination hove into sight. The cable terminated in a knot of dozens of others, at a complicated cagework that threaded the axle of a town-wheel. Venera could see other people embarking and disembarking there. They moved in small groups that gave one another a wide berth.

She saw something else, though, that gave her hope for the first time in days: ships were berthed here. Sleek yachts, for the most part, of many different designs and flying diverse colors—but all foreign. They signaled the possibility of escape, real escape, for the first time since her arrival.

She tapped Odess's tin shoulder and pointed. "Our customers?"

He nodded. "Pilgrims from all the principalities of Candesce come to us, hoping to leave again with some trinket or token of ours. Do you recognize any of those ships?"

Venera nodded. "That one is from Gehellen." It was the only one she knew, but Odess was obviously impressed. "I know that we'll trade them cherries," she went on. "But what do the rest of Spyre's countries sell?"

He laughed, and just then the platform came to rest at its terminus. As they clambered over to the axle like so many iron spiders, Odess said, "What do they trade? You ask that with refreshing innocence. If we knew what half our neighbors traded, we might arrange some extra advantage for Liris. The fame of many of Spyre's commodities is spread far and wide—but not all. There are sections of the fair no stranger can enter without providing a guarantee of circumspection."

"A what?"

"A hostage, sometimes," said Eilen. They had entered a long cylindrical chamber with many small doors spiraling up its interior. Odess found one of these and, producing a massive key, unlocked it. Inside was a slot-shaped locker, its walls encrusted with rust and cobwebs, with one incongruously bright mirror at the far end. Odess and the others proceeded to strip off their metal shells, trading them for ornately tooled leather equivalents—except that in place of veils, each costume came with an elaborate mask. Odess passed a kit to Venera, and she turned her back modestly to change. Her mask had a falcon's beak.

"There are nations," Odess said, "that average one customer every ten years. Whatever it is they trade, it is so fabulously valuable that the whole country lives off the sale for a generation. That's an extreme example, but there are many others who guard the nature of their produce with their lives. Liris used to be one such. Now everyone knows what we produce, but that's actually worked to our advantage."

"But what can those others be selling?" Venera shook her head in incomprehension. She was stretching a black jacket over a silver-traced vest, admiring the effect in the mirror. With the mask in place she looked intimidating. She liked the effect.

"*She* is from one of them." It was one of the soldiers who said it. He didn't have to say who *she* was; Venera knew he meant the botanist.

Venera raised an eyebrow. "She wasn't born in Liris?"

The soldier shook his head, glancing

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uneasily at Odess. "Our previous botanist . . . the trees were languishing, m'lady. They were dying, until she came." Odess was scowling in obvious warning, but the soldier shrugged. "Five years now, she's brought them back to health."

"And you don't know anything about where she came from?"

"Of course we do!" Odess laughed loudly. "She's a lady of the Nation of Sacrus. We know who she is . . . even if we don't know what it is that Sacrus *does*."

"You need better spies," said Venera. Nobody laughed, but the thought intrigued her. Spyre, it seemed, was an investigator's playground. She would love to develop a network here, the way she had in secret in her adopted home of Slipstream.

They moved from the locker cylinder to the axle of the town-wheel. Here, dozens of yin-yang stairs and elevator shafts ran down to the copper-shingled roofs of the vast buildings lining the wheel. Odess showed their letters of transit to a succession of inspectors and gradually they worked their way over to one of the elevators.

"Stay alert, everyone," Odess said as the wrought-iron doors grumbled shut behind them, and they began to move down. "Watch for any signs of change. In particular, our new interpreter," he nodded at Venera, "is going to cause a stir. We need to stick to our agreed story. You," he said to Venera, "must only speak to the customers, and then only when we ask you to. We don't want to give our rivals any clues about our capabilities or what's been going on inside Liris."

This paranoia reminded Venera of Hale and the darkened corridors of her father's palace. "But why?" she asked in irritation. "Why this skulking?"

"Questions might be asked," said Odess darkly. "About where you came from. About why our people might have ventured outside our walls. Where we might have gone, what we might have seen. What *you* might have seen." He shook his head. "Your story is that you were born and raised in Liris."

"But my accent—"

"Is why you will only speak to the customers."

There was silence for the rest of the ride. Venera adjusted her veil, glanced around, and noted the tightening of shoulders, straightening of stances as gravity rose until it neared the level she was used to. And then the elevator clunked to a halt, and the doors opened.

The trade delegation of Liris edged cautiously into the Great Fair of Spyre.

Fabulous beasts swept across the dance floor, their skirts wheeling in time to the deep drumbeat of Spyre's music. The beasts had the faces of monsters, of animals, of gods. They danced in pairs, sometimes pausing in midpose as the music paused. It was during those pauses that business was transacted.

One slender figure with a hawk's face stood at the foot of a gold-chased pillar, her backdrop a blue *trompe l'oeil* vista of wheeling towns. She watched the dancers alertly, aware of the deep strains of paranoia and deceit that must run through Spyre for it to have developed this custom. For this filigreed and gleaming ballroom and its whirling dancers was the Great Fair itself.

True, there were display rooms. Out of the corner of her eye she saw Odess emerging from the doorway that led to Liris's. He was alone, and doubtless his errand had been to check on the disposition of the glass cases and lights there. No customers had passed that door since she had been here.

Venera had spent some hours in the display room, helping the others set up. A solitary cherry tree dominated the marbled parlor; it sat in a broad stone bowl, the glow of its pink blossoms the first sight that greeted a visitor. It was a fake, made of silk and common woods.

While Liris's soldiers played cards be-

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hind a screen in the display rooms, the rest of the delegation danced. The music was loud, the dances fast and close; so conversation consisted of quick whispers in your partner's ear, quips at arm's length, or brief nose to nose exchanges. Eavesdropping was impossible in these circumstances—and the soldiers of Spyre watched carefully for any sign of it. Venera had been told that visitors were carefully screened, and the penalty for revealing secrets here was death. Ironically, the whole setup seemed designed for cheating, for who could tell what any two dancers were telling one another?

She had heard that the dances were occasionally interrupted by spontaneous duels.

The denizens of Spyre took their masque very seriously. Not all the visitors did; most eschewed disguises, and so Venera was able to tell how many principalities were represented here. She even recognized one or two of the national costumes they wore.

A gavotte ended and the dancers broke up. Gorgon-headed Eilen headed Venera's way. A waiting footman handed her a drink as she paused, panting. "Is it always like this?" Venera asked her. "Interested customers seem a bit thin on the ground."

"We have our regulars," said Eilen. "It's not the season for any of them. Oh, this gravity! It pulls at my stomach."

Venera sighed. These people were so immersed in their traditions that they couldn't see the insanity of it all. In the brief pause between dances, some of the customers had drifted off with outlandishly masked delegates—salesmen, really. Venera had been keeping track of who went through which doorways. Many of the portals around the vast chamber had never opened. They might be locked or even bricked up on the other side, for all she knew.

She couldn't figure out the architecture of the fair. It seemed that the sprawling, multi-winged building had been renovated, rebuilt, and reimagined so many times over the centuries that it had lost any sense of its original logic. Corridors ran into blank walls; stairwells led nowhere; elevator shafts opened onto roaring air where lower floors had once been. Behind the public walls countless narrow passages twisted their ways to the offices, storage lockers, and panic rooms of the trade delegations. Liris's domain extended several floors above and below their public showroom; Venera had glimpsed in passing a huge chamber, like a collapsing ballroom, its dripping casements lost in gloomy shadows. Eilen had told her that this was where they met customers back when their cherries were a state secret. The ballroom was on one of the high-security levels of the fair; Liris still owned title to it, but had no use for it now.

Venera had scoffed at this. "Has no one had the courage to drill spy holes in the walls to find out what your neighbors are up to?" Odess had sent her one of his disapproving, frightened looks, but nobody had said anything.

Oh, something was happening—Capri, Eilen's apprentice, was leading four people in rich clothes toward the Liris door. The little surge of excitement was absurd, and Venera nearly laughed at herself. Now Odess was bowing to them. He was opening the door. Venera imagined cheering.

"Who are they?" she asked Eilen.

"Oh! Success! That's . . . let's see . . . the delegates from Tracoune."

Venera ransacked her memory; why was that word familiar? Ah, that was it. It was only a couple of weeks ago that Venera and her husband had attended a soiree in the capital of Gehellen. The event had been unremarkable up until the shooting started, but she did remember a long conversation with a red-faced admiral of the local navy. He had mentioned Tracoune.

"Excuse me, I'd like to watch this," she said to Eilen. The woman shrugged

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and turned back to the dance. Venera threaded her way around the outskirts of the ball and pushed open the door to the Liris showroom. It was at the end of a long hallway, seventy feet at least in length. Random words echoed back at her as Venera walked down it.

Odess was showing them the tree. Now he was opening a lacquered box to reveal the cherries. Capri hovered nervously in the background.

The visitors didn't seem too impressed. One of the four—a woman—wandered away from the others to stare idly at the paintings on the walls. They seemed to be marking time here, perhaps taking a break from dancing. Even Venera, with no experience in sales, could tell that.

She approached the woman. "Excuse me . . ." said Venera. She deliberately did not stand or move the way Odess and Capri were—clasping their hands in front of them, darting hesitantly like servants. Instead, Venera bowed like an equal.

"Yes?" The customer looked surprised, but not displeased at being approached in this way.

"Do I have the pleasure of addressing a citizen of Tracoune?" The woman nodded.

"I had the most illuminating conversation recently," Venera continued, "at a party in Gehellen. We talked about Tracoune."

An edge of calculation came into the woman's gaze. "Oh, really? Who were you talking to?"

"An admiral in the Gehellen navy, as it happens." Venera saw Odess notice that she was accosting a customer (his expression said, 'the new one's loose!') and then he started trying to make eye contact with her while pretending to give his full attention to his own people.

Venera smiled. "I'm so sorry that you've had to cancel the Feast of Saint Jackson this year," she said to her prospect. "The Gehellenese are speculating that you won't be able to afford to feed your own people this time next year. Gauche of them, really."

"They said that?" The woman's face darkened in anger. "The Incident at Tibo was hardly that serious!"

"Ah, we thought not," said Venera in a conspiratorial way. "It's just that appearance is so important to international relations, isn't it?"

Ten minutes later the visitors were signing on the dotted line. Venera stood behind the astounded trade delegation of Liris, her arms crossed, inscrutable behind her beaked mask.

Odess stepped back to whisper furiously to her. "How did you do it? These people have never been customers before!"

She shrugged. "You just have to know people's weaknesses. In a few weeks Tracoune will throw some minor party for visiting officials, and among other things they'll give away a few cherries . . . as if they could afford boatloads of them. A very discreet message, on a channel so private that almost no one on either side will know why when the Gehellens decide *not* to call in their outstanding loans to Tracoune—which they've been thinking of doing."

He glared at her. "But how could . . ."

She nodded. "The levers of diplomacy are very small. The art lies in knowing where to pry."

Venera chatted with the clients while a soldier loaded a carrying case with dry ice and Odess measured out the pitted cherries. "Speaking of Gehellen," Venera said after a while, "we heard about some sort of commotion there a couple of weeks ago."

The head of the Tracoune expedition laughed. "Oh, that! They're the laughingstock of the principalities!"

"But what happened?"

He grinned. "Visitors from one of the savage nations . . . Oh, what was the name?"

"Slipstream," said the woman Venera had first dealt with.

"Slipstream, that was it. Seems an ad-

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miral of Slipstream went mad and took to piracy with some of his captains. They fought a pitched battle with the Gehellen navy in the very capital itself! Smashed their way out of the palace and escaped into Leaf's Choir, where it's rumored they found and made off with the Hoard of Anetene itself!"

"But that part's too preposterous, of course," said the woman. "If they'd found the hoard, they would have a key to Candesce as well—the last one is supposed to be the centerpiece of the hoard. With that they could have ruled all of Virga from the sun of suns itself!"

"Well." The man shrugged.

"What happened to them?" asked Venera. "Did they escape?"

"Oh, they evaded the Gehellen navy right enough," he said with another laugh. "Only to be cut to ribbons in some barbarous nation near the edge of the world. None escaped, I hear."

"None . . ." Venera's pulse was racing, but she chose not to believe this man. His story had too many of the facets of rumor.

"Oh, no, I've been following this one," said the woman, with evident enjoyment. "It seems the Slipstreamers ran afoul of a place called Falcon Formation. The admiral suicidally rammed his flagship into some sort of dreadnaught of Falcon's. Both ships were obliterated in the explosion. Of his six other ships, only one got away."

"Its name?" Venera put her hand out to steady herself. Her fingers met the false bark of the fake cherry tree.

"What's name?"

"The . . . the ship that escaped. Did you hear which one escaped?"

The woman looked affronted. "I didn't follow the story *that* closely." Now it was her turn to laugh. "But they foolishly ran for home, and the Pilot of Slipstream had them arrested the instant they came into port. For treason! What foolishness of them to even try to go home."

Venera was glad of the mask she wore. It felt like her heart was slowing and would stop at any second. It was all she could do to keep up appearances until the Tracoune delegation left with their first consignment of cherries. Then she rushed back to the screened alcove, ignoring the jubilant congratulations the others were lavishing on her.

Even though the mask would have hid them, she shed no tears. Venera had learned many years ago never to do that in the presence of another human being.

5

That evening there was a celebration in a gallery overlooking the cherry trees. Amber light poured into the blued central shaft, glinting off windows and outlining shutters and balconies above and below, while small gusts of air still warm from Candesce's light teased the diaphanous drapes. Like everywhere else in Liris, the party room was small, crammed with memorabilia and eccentric furnishings, and reachable only through a labyrinth of stairs and corridors. It reminded Venera of her childhood bedroom.

She had not wanted to come. All she wanted to do was sit alone in her closet. But Eilen insisted. "Why so gloomy?" she asked as she leaned hipshot in Venera's doorway. "You did great service to your country today!" Venera didn't speak as they walked, and she did her best to be the ghost at the wedding for the remainder of the night.

Her sorrow wasn't catching. Most of Liris turned out for the event, and a dizzying parade of strange and neurotic characters passed in front of Venera as she systematically drank herself into a stupor. There were the hereditary soldiers with their peaked helmets and blunderbusses; the gray sanitation men who spoke in monotones and huddled together near the drinks table; the seamstresses and chandlers, carpenters, and cleaners who all spoke a secret language they had developed together in their childhood. And there were children,

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too—grave, wide-eyed gamins who skirted around Venera as though she had stepped out of one of their fantasy books.

She watched them all go by, numb. *I knew that this might happen*, she told herself. *That he might die*. Yet she had gone ahead with her plan, dragging Chaison reluctantly into it. It had been necessary if they were to save Slipstream; she knew that. But the decision still felt like a betrayal.

"It's so *electric*," said Eilen now, "having a new face in our world!" Quite drunk, she balanced on one foot near Venera, waving excitedly at people she had seen every day of her life. Of those people, a few had approached and introduced themselves, halting and stammering; most stayed back, muttering together and eyeing Venera. Foreigner. Strange beast. New darling of the botanist.

And yes, the botanist was here, too. She glided through the celebrants as though on rails, nodding here and there, speaking strategic words on the outskirts of discussions, the same mysterious smile as always hovering just behind her lips. Eventually she made her way over to Venera. She hove to just this side of Eilen. Eilen herself moved away, suddenly quiet.

"I've always said that it pays to know your customers," the botanist said. "I judged your potential rightly."

Venera eyed her. "Is that what you feel you do? Judge people's potential? Like the buds of flowers that might bloom or whither?"

"How apt. Yes, that's exactly right," said the botanist. "Some are to be encouraged, others cut from the branch. You nod as though you understand."

"I've done a certain amount of . . . pruning . . . in my day," said Venera. "So I've achieved a great victory for your tiny nation. Now what?"

"Now," said the botanist in a breathless sort of sisterly way, "we talk about what to do next. You see, you've vindicated my methods. I believe Liris needs to be more open to the outside world—that we need to send our delegates farther, even outside Spyre itself."

The fog of Venera's sorrow lifted just a bit. "Leave Spyre? What do you mean?"

"I would like to send a trade mission to one of the principalities," said the botanist. "You, of course, would lead it."

"I'd be honored," said Venera with a straight face. "But isn't it Odess's job to arrange such things?"

"Odess?" The botanist waved her hand dismissively. "Prattling whiner. Take him if you'd like, but I can't see what good he'll do you. No, I picture you, perhaps Eilen, and one or two loyal soldiers. And a consignment of our treasure to tempt potential customers."

"That sounds reasonable." Venera couldn't believe what she was hearing. Did the woman seriously believe she would come back if she got out of this place? But then, everyone in Spyre seemed dangerously naive.

"Good. Say nothing of this to the others," instructed the botanist severely. "It won't do to let old wounds fester."

What did that mean? Venera thought about it as the botanist strolled away, but then Eilen returned and spilled her drink on Venera's shoes. The evening went downhill from there, and so she didn't really ponder the botanist's unlikely offer until she got back to her closet, near dawn.

She had just closed the ill-fitting door and was about to climb under the covers when there was a polite knock on the jamb. Venera cracked the door an inch.

Moss leaned like a decapitated tree outside her door. "Citizen F-f-fanning," he said. "I j-just wanted to give you th-th-these."

In the faint lamplight of the hallway, she could just make out a tiny bouquet of posies in his hand.

The juxtaposition of his chiseled features with the emptiness of his eyes made her skin crawl. Venera slipped her

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hand out to snatch the little bundle of flowers from his nerveless fingers. "Thanks. You're not in love with me, are you?"

"I'm s-s-sorry you're so s-sad," he murmured. "T-t-try not to be so s-s-sad."

Venera gaped at him. His words had been so quiet, but they seemed to echo on and on in the silent corridor. "Sad? Why do you think I'm sad?"

Nobody else had noticed—not even Eilen, who had been watching Venera like a mother hawk all evening. Venera narrowed her eyes. "I didn't see you at the party. Where were you?"

"I w-w-was there. In the c-corner."

Present yet absent. That seemed to sum Moss up. "Well." Venera looked down at Moss's present. Somehow she had clenched her fist and had crushed the little white blossoms.

"Thank you," she said. Moss turned away with a muted clattering noise. "Moss," she said quickly. He looked back.

"I don't want you to be sad, either," said Venera.

He shambled away and Venera closed the door softly. Once alone, she let loose one long shuddering sigh and tumbled face-first onto the bed.

The next morning, Venera wore the half-crushed posies on the breast of her jacket. If anybody noticed, they said nothing. She ate her breakfast with the members of the delegation in their designated dining room—a roofed-over airshaft lined floor to invisible ceiling with stuffed animals—and followed them silently to their offices. She had discerned the routine by now: they would sit around for the rest of the day, occasionally engaging in desultory, short-lived dialogs, have lunch and then supper, and turn in.

If she had to live like this for more than a couple of days, Venera knew she would snap. So, at ten o'clock, she said, "Can't we at least play cards?"

One of the soldiers glanced over, then shook his head mournfully. "Odess always wins."

"But I'm here now," said Venera. "What if I were to win?"

Slowly, they roused into a state resembling the attentive. With much cajoling and browbeating, Venera got them to reveal the location of the cards, and once she had these she energetically pulled a table and some chairs into the center of the room. "Sit," she commanded, "and learn."

This was her opportunity to grill her compatriots properly—the party last night had been too hectic and strange, with everyone playing pal in transparent ways—and Venera made the best of it. After ten minutes Odess emerged from his office, looking bleary and cross, but his eyes lit up when he saw her shuffling the cards. Venera grinned sloppily at him and he drew up a chair.

"So," she said as the others examined their cards, "tell me about the botanist."

The Pantry War had been dragging on for five years. Liris and the Duchy of Vatoris both claimed a five- by seven-foot room off one of the twisting corridors of the fair. The titles went back a hundred years, and the wording was ambiguous. Neither side would back down.

"War?" said Venera as she peered over her cards. "Don't you mean feud?"

The other players all shook their heads. No, explained Odess, a feud was a family thing. This was a conflict between professional soldiers, and it took the form of pitched battles—even if those battles were between a dozen or so soldiers on either side, which was all the manpower the tiny nations could muster. After years of ambushes, raids, firefights, and all manner of other mayhem, it had settled into a war of attrition. Barricades had been thrown up in the disputed corridor, a no-man's-land of broken furniture and cracked tile stretched for thirty feet between them. The entrance to the closet beckoned only yards away, and either side could

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capture it in seconds. The trick was to hold it.

The two sides dug in. The barricades were ramified and reinforced, then backed up with cannon and rifles. Days might pass without a shot fired, but the other tenants of the fair got used to sudden flurries of gunfire. Rarely was anyone actually hurt. The loss of a single man would constitute a disaster.

These things happened. Even now, the fair was riddled with strange tensions—empty passages paved in dust where no one had walked in generations because of just such disputes as this; neighbors who would think nothing of murdering one another in quiet corners if they had the chance; victims walled up in alcoves; and everywhere, conspiracies.

It was a random bullet that changed everything. The walls around the disputed hallway had never been strong, but the combatants had hired a neutral third party to shore them up at regular intervals. Perhaps it was inevitable, though, that chinks and cracks should develop. One day, a bullet fired from the Vatoris barricade slipped through such a crack, ricocheted sixty feet down an abandoned air shaft, and killed the heir of a major nation as he stood at a punch bowl.

Venera rubbed her jaw. "I can imagine the reaction."

"I'm not sure you can," said Odess portentously. The nation in question was the mysterious Land of Sacrus, a country of "vast size," according to Eilen.

"How vast?"

"Fully three square miles!"

Sacrus traded in power—but exactly how, no one was quite sure. They were one of the most secretive of countries, their fields being dotted with windowless factories, the perimeter patrolled by guards with dogs and guns. Small airships bristling with guns bobbed above the main complex. The Sacrans emerged from their smoke-wreathed towers only once or twice a year, and then they spoke almost exclusively to their customers. They were one of the few nations that had withstood the full force of the preservationists—in fact, nobody in the preservationist camp would talk about just how badly that particular battle had gone.

Sacrus was enraged at the death of their heir. Three days after the incident, the Vatoris barricade fell silent. The soldiers of Liris fired a few shots and got no response. When they cautiously advanced on the Vatoris position, they found it abandoned.

Discrete inquiries were made. No one had seen any of the Vatorins since the day of the fateful gunshot. In a moment of supreme daring, Liris sent its troops directly to the Vatoris apartments. They were empty.

At this point, rumors of a great stench rising from Vatoris itself reached Odess's ears. "I was sitting in our showroom," he said. "I remember it like it was yesterday. One of the scions of a minor nation entered and told me that his people were walking up and down along the border with Vatoris, sniffing the air and exchanging rumors. The smell was the smell of death."

Odess returned home that night to warn his people. "But it was too late. As I lay down to sleep that evening, I heard it—we all did." A hissing sound filled the chambers of Liris. It was faint, but for someone like Odess, who had lived behind these walls his whole life, it had the effect of a siren.

"I stood, tried to run to the door. I fell down." The others related similar experiences, of sudden paralysis, landings behind desks or next to wavering doors. "We lay there helpless, all of us, unable to even focus our eyes. And we *listened.*"

What they heard, after an hour or so, was a single set of footsteps. They moved smoothly from room to room, up stairs and down, not as if seeking anything, but as though whoever walked

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were taking inventory—committing every passage and chamber of Liris to memory. Eventually, they came to a stop. Silence returned.

The paralysis faded near dawn. Odess rose, retched miserably for a few minutes, and then—trembling—crept in the direction those footsteps had taken. As he went he saw others emerging from their rooms, or rising from where they had fallen in mid walk. They converged on the place where the footsteps had halted: in the cherry tree courtyard.

"And there she sat," said Odess, "exactly as she sits these days, with the same damned smile and the same damned air of superiority. The botanist. Our conqueror."

"And no one has challenged her?" Venera barked a laugh of disbelief. "You fear reprisals, is that it?"

Odess shrugged. "She ended the war, and under her leadership, the cherries bloom. Who else are we going to have lead us?"

Venera scowled at her cards. A pulse of pain shot up her jaw. "I thought you were a meritocracy."

"And so we are. And she is the best botanist we have ever had."

"What happened to the one she replaced?"

They exchanged glances. "We don't know," confessed Eilen. "He disappeared the day Margit came."

Venera discarded one card and took another from the deck. The others did the same, then she fanned out her hand. "I win."

Odess grimaced and began to shuffle.

"She came to me last night," said Venera. She had decided that she needed information more than discretion at this point. "Margit was pleased with the work I did." Odess snorted; Venera ignored him and continued. "She had a proposal."

She told them about Margit's idea of an extended trade expedition into the principalities. As she did, Venera watched all movement around the table stop. Even Odess's practiced hand ceased its fanning of the cards. They were all staring at her.

"What?" She glanced around defensively. "Does this violate some ancient taboo?—I'm sure, everything else does. Or is it something you've been trying to get done for years, and now you're mad that the newcomer has achieved it?"

Eilen looked down. "It's been tried before," she said in a quiet voice.

"You must understand," said Odess; then he fell silent. Knitting his brows, he started furiously shuffling.

"What?" Now Venera was seriously alarmed. "What's wrong?"

"To travel outside Spyre . . . is not done," said Odess reluctantly. "Not without safeguards to guarantee one's return. Hostages, if one is married . . . but you're not."

Venera was disgusted. "The pillboxes, the guns and razor wire—they really aren't to keep people *out,* are they? They're to keep them in."

"Yes, but you see, if Margit is willing to send you out despite you having no ties here, no hostages or anything she could hold over you . . . Then she's obviously willing to try it again," said Odess. *He slammed the deck down on the* table, kicked his chair back, and walked away. Venera watched him go in startled amazement.

The soldiers were standing too, not making eye contact with anyone.

Venera pinned Eilen with her gaze. "Try *what?"*

The woman sighed deeply. "Margit is a master of chemistry and biology," she said. "That's why she is the botanist. Three years ago she conceived the idea of sending an expedition like the one you're describing. She chose a man who was competent, intelligent, and brave, but one whom she didn't completely trust. To guarantee that he would return, she . . . injected him. With a slow poison that was not supposed to begin to act for ten days. If he returned within those ten days, she would give him the

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antidote, and he would be fine."

Venera eyed the splayed cards. "What happened?"

"The return flight was delayed by a storm. He made it back on the eleventh day."

Venera hesitated—but she already knew the answer when she asked, "Who was it that Margit sent?"

"Moss," said Eilen with a shudder. "She sent Moss."

6

"I have to admit I was expecting this," said Margit. Venera stood in the doorway to her apartment; she was dressed down in close-fitting black leathers. Two soldiers hulked behind her, their meaty hands resting heavy on her shoulders.

"In retrospect," Venera said ruefully, "I should have anticipated the trip wires." The inside walls of the courtyard were just too enticing a surface; freed of her metal clothing, Venera weighed only twenty pounds or so and she could easily clamber hand-over-hand up the drainpipe that ran next to Odess's little window. "There's no other way in or out of the building but up that wall. Naturally, you'd have alarms."

". . . I just wasn't anticipating it so soon," said Margit. She twitched a housecoat over her lavender nightgown and lit another candle off the one she was holding. Even in the dimness of midnight Venera could see that her apartment was sumptuous, with several rooms, high ceilings, and tiled mosaics on the floor beneath numerous tapestries.

Of course Margit wouldn't live like the people she ruled. Venera wouldn't have, either. She understood Margit enough by now that staying here in Liris had not been an option. So after bidding her coworkers good night, she had retired to her closet and waited. When the building was silent and dark, Venera had crept out and jimmied open a window that led onto the courtyard.

Admittedly, she hadn't been thinking clearly. The revelation about Moss had shaken her and she had acted rashly. If she didn't regain control of this situation she would be in real trouble.

"Come in, sit down. We need to talk," said Margit. "You may leave us," she said to the soldiers. They lifted their hands off Venera's shoulders and retreated past the heavy oak door. They would have a long walk down the winding steps that led down to Liris's ground floor. *Good*, thought Venera.

She sat down on a decadent-looking divan, but she kept her feet braced against the floor, ready to leap up instantly if that was required.

The first step to taking control of the situation was taking control of the conversation. Margit opened her mouth, but Venera spoke first: "What is an heir of Sacrus doing running a minor nation like Liris?"

Margit narrowed her eyes. "Shouldn't I be asking the questions? Besides, what's your interest?" she asked as she gracefully sat opposite Venera. "Professional curiosity, perhaps? You are a noble daughter yourself, are you not? A nation like Liris would be an interesting playground for someone learning how to use power. Are you interested in rulership?"

"In the abstract," said Venera. "It's not an ambition of mine."

"Neither is assisting your new countrymen, I gather. You were trying to escape us."

"Of course I was. I was press-ganged into your service. And you admit yourself you expected me to try it." She shrugged. "So what could we possibly have to talk about?"

"A great deal, actually," said Margit. "Such as how you came to be here at all."

Venera nodded slowly. She had been thinking about that, and the conclusions she had come to had motivated her to run as much as the facts about Moss. "I arrived here through an odd chain of events," she said. "At the time I wasn't

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prepared to wonder why there were armed troops sneaking over the lawns of Spyre during the nighttime. I was mostly concerned with evading them. But they pursued me here. Why here? At the time, I didn't know enough to even ask the question."

Margit raised an eyebrow and sat back.

"It's my father, you see," said Venera in a confessional tone. "He's flagrantly paranoid, and he wanted his daughters to be as well. He raised me to disbelieve coincidence. So if I was *herded* here, what could the reason be? The troops who were following me weren't from Liris. In fact, I assumed they weren't after me at all, but were chasing down another trespasser whom I had met. It wasn't until today that I realized that those other soldiers had been from Sacrus."

Margit laughed. "That truly is paranoid. You would implicate my nation in every one of your misfortunes?"

"No, just this one." She sat forward. "Since we're talking, though, I'd like to ask you a couple of questions." Smiling her maddening smile, Margit nodded. "The first question is whether you maintain constant contact with your nation. I've been told you don't, but I don't believe that."

Margit shrugged. "It would be easy. So what if I did? Can't a daughter talk to her parents?"

"The second question," said Venera, "is whether Sacrus itself travels regularly into the principalities." Seeing Margit's suddenly guarded expression, Venera nodded. "You do, don't you?"

"So what?"

"Someone guessed where I had come from," marveled Venera. "More than likely the Gehellens have circulated descriptions of myself and my husband throughout the principalities. They seek us, and it's an open secret why."

Margit grinned in obvious delight. "Oh, you are smart! I was right to bring you into Liris in the way I did."

Venera cocked her head. "What other way was there?"

"Oh, I think you can guess."

"Under duress. Tortured," said Venera. "Why do you think I tried to flee just now? It suddenly made no sense to me that I was walking around freely. And your offer to let me travel outside Spyre . . . made even less sense."

"You became alarmed. That's understandable. I was told to learn everything you know about the Key to Candesce," said Margit. "You figured that out, of course."

Venera looked innocent. "Sorry, the what?"

Margit stood up and paced over to a side table. "Drink?" Venera shook her head.

"Something happened a short time ago," said the botanist. She stood with her back to Venera, and in those seconds Venera looked around quickly for anything that might give her an advantage. There were no handy hat-pins, letter openers, or pistols lying on the pillowed furniture. She did spot a battered wooden cabinet that looked markedly out of place compared to the rest of the pieces, but had no time to get to it before Margit turned again, drink in hand.

"Something happened," Margit repeated, "a fight in the capital of Gehellen, rumors of a stolen treasure, and then an event that our scientists are starting to refer to as *the outage.*"

Venera tensed. She hadn't expected Margit to know this part of the story.

"Candesce does many things besides light our skies," said the botanist. "We watch the sun of suns closely; we have to, our very lives depend on it. So when one of Candesce's many systems shuts down, even for a moment, we know about it. Even though such an event has not occurred in living memory."

She sat down again. "Only someone with a key could enter Candesce and manipulate it. And the last key was lost centuries ago. You can imagine the uproar that the outage has caused, here

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and abroad. The principalities are mobilizing, and agents of the Virga Home Guard have been seen nosing around, even here."

Home guard? Venera had never heard of them. But she wanted to kick herself for failing to realize that the gambit she and her husband had played would alert all the powers in the world. *Hit another trip wire*, she mused.

"It was only a matter of days before we had your name and description and that of your husband and others in your party," said Margit. "We pay our spies well. So when a woman fitting that description miraculously appeared in the skies of Greater Spyre, we acted."

"Clearly, I've been a fool," said Venera bitterly. "Then it was Sacrus troops who drove me here?"

"I actually don't know for sure," Margit admitted. "Our men were out that night, I know that much. But there may have been others as well. In any case, once I communicated that I had you, I was told to hand you and the key over. I couldn't very well refuse my masters the key—but you, I declined to part with."

Venera felt a pulse of anxious anger as she realized what Margit was saying. "Then the key is—"

"Locked away in the Gray Infirmary, where Sacrus keeps all their new acquisitions," said Margit with some smugness. She drained her wineglass and tilted it at Venera. "But you're here. I took Liris in order to have a base from which to grow my own power. You provide potential leverage. Why should I give you up?"

"And the offer to let me travel . . . ?"

"I increase my leverage and buy some insurance by getting you out of Spyre and to a safe place that only I know about," said Margit. "But you should really be happy that I haven't tortured you for what you know. I'd prefer to have you on my side. You must admit, I've treated you well."

Cautiously, Venera nodded. "It was too risky to keep the key to Candesce for yourself. But a lesser piece of leverage . . ."

". . . Who knows something vital about it that I can trade . . . that's useful to me at the moment." Margit smiled, catlike.

It still didn't quite add up. "Why did you let me go up to Lesser Spyre?" Venera asked. "Why risk exposing me at the fair?"

"That was to prove that I had you," said Margit with a shrug. "While I was negotiating what to give up. Sacrus was at the fair. I told them to watch for you, but with the guards and defenses that surround the fair, they couldn't snatch you from me. It was the safest place in Spyre to display you."

Someone unused to being used as a political pawn might have been surprised at these revelations. For Venera, discovering that she had been played was almost reassuring. It placed her in a familiar role.

She knew exactly what Sacrus was going to do now. Venera had fantasized about it herself: you took the key and entered Candesce, and then shut down the sun of suns. As the darkness and cold began to seep into the principalities, you made your demands of the millions whose lives depended on Candesce. You could ask for anything—power, money, hostages, or slaves. Your leverage would be total.

It would help to have enough experienced men to crew a navy, though, because one of your first demands would be that the principalities deliver up their own ships. "Sacrus doesn't have any ships, do they?" she asked. "Surely not enough to run the blockade that the principalities would put in place."

Margit shrugged. "Oh, we have several. Sacrus is a big nation. But in terms of weapons . . ." She laughed, and it wasn't a pleasant laugh. "I doubt we would have to worry much about any fleet of the principalities."

Her confidence was suddenly unnerving. Margit sauntered over to the bat-

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tered wooden cabinet and opened the top. "Since you're here," she said, "let's talk about the key to Candesce."

"Let's not." Venera stood up. "My knowledge is my only bargaining chip, after all. I'm not going to squander that."

This time Margit didn't answer. She pulled a bell-rope that hung next to the cabinet.

The gravity was low enough and Venera still strong enough that she could probably make it to the window in one leap. Then she could scale the stonework by the tips of her fingers if she had to and make it to the roof in under a minute. Not, however, faster than the soldiers could climb a flight of stairs to retrieve her.

Margit was watching her calculate her options. The botanist laughed as the door opened behind Venera and a large, heavily armored soldier entered.

"I'm not going to hurt you," said Margit. Something glittered in her hand as she approached Venera. "I just want to guarantee your compliance from now on."

"The way you tried with Moss?" Venera nodded at the syringe Margit held. "Is that the same stuff you used on him?"

"It is. His outcome was an accident," said the botanist as the soldier stepped forward and grabbed Venera's wrists from behind. "I'll be more careful with you."

His outcome was an accident. Venera was familiar with that sort of logic, she often blamed others for the things she did to them. For some reason, the argument didn't work this time.

Margit had to round a large couch as she approached Venera. She took a step to do so, and Venera made fists, bent her forearms forward, and then raised her arms in an egg-shaped curve that Chaison had once showed her. The startled soldier clung tightly to her wrists but suddenly found himself pulled forward and off balance as Venera lifted his hands over her head. And then she turned and her hands were over his as he lost his grip, and she pushed down and he thumped onto his knees.

She kicked him in the face. His helmet ricocheted across the room as Margit shouted, and Venera hopped the couch, snatching up the open wine bottle and swinging it at the botanist's head.

Margit slashed out with the syringe, nicking Venera's sleeve. They circled for a second and then Venera grabbed for her wrist and they tumbled onto the floor.

The wine bottle skittered away, gouting red. Venera pulled Margit's arm up and bit her wrist. As the botanist let go Venera made a grab for the syringe. Margit in turn lunged for the bottle.

"I was just going to kill you," hissed Venera. She landed on Margit's back as the botanist closed her fingers on the bottle. "I've changed my mind!" She jammed the needle into Margit's shoulder and pushed the plunger.

Margit shrieked and rolled away. Venera let her. The botanist had let go of the wine bottle, and Venera took it and upended it over the wooden cabinet.

Cursing and holding her shoulder, Margit ran over to the soldier, who was sitting up. When she saw Venera reach for one of the lit candles she screamed *"No!"* and backpedaled.

It was too late, as Venera touched the candle flame to the wine-soaked cabinet and the whole thing caught. In the orange light of the fire, Venera ran through a nearby arch. She wanted to know whether that cabinet was all there was to Margit's power.

"Ah . . ." She stood in a large private pharmacy—dozens of shelves covered in glass bottles of all sizes and colors hung above long work tables crowded with beakers, petri dishes, and test tubes. Venera joyfully swept her arm across a table and tossed the candle into the cascading glasswork as Margit clawed at her from behind.

There was fire behind them, now fire ahead and smoke wafting up to the ceiling as Margit pushed and kicked at Ven-

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era and tried to get past her. When the soldier finally appeared out of the smoke, Venera stood over the botanist, her nose bleeding but a grin of utter savagery on her face. She brandished a long knife she'd found on the table.

"Back away or I'll cut her throat!" Venera's backdrop was flames. The soldier backed away.

Shouts of alarm and clanging bells were waking the house. Venera dragged Margit out of the inferno and threw her to the floor in front of the smoldering cabinet.

"Ten days." She pointed to the door. "You have ten days to convince your people to save you. I have no doubt that Sacrus has the antidote to your poison, but you'll have to go to them on bended knee to get it. For your sake I hope they're in a forgiving mood."

People were crowding in the doorway—men and women carrying buckets of sand and water, all shouting at once and all clattering to a halt at the sight of Venera standing over the all-powerful botanist.

"You are no longer the botanist of Liris!" Venera raised her arm, summoning everything she had learned from her father about how to intimidate a crowd. "Let no one here ever grant entry to this woman again! *Run!* Run home to Sacrus and beg for your life. This place is closed to you."

Margit staggered to her feet, clutching her shoulder. "I'll kill you!" she hissed.

"Only if you've a mind to do it," said Venera. "Now go!"

The botanist ran for the door, pushing aside the stunned firefighters.

"Get with it!" Venera yelled at them. "Before the whole house goes up!"

She walked through them, and as more came up the stairs, she politely eased to the side to let them pass. She reached the main floor of Liris to find all the lights lit and a confused mob swirling around the strangely decorated desks and counters.

"What's happened?" Odess emerged from the rush of faces. The rest of the trade delegation was behind him.

"I've deposed the botanist," said Venera. They gaped at her. She sighed. "It wasn't *that* hard," she said.

"But—but how?" They crowded around her.

"But *why?*" Eilen had grabbed her arm.

Venera looked up at her. Suddenly she felt tears in her eyes.

"My . . . my husband," she whispered through a suddenly tight throat. "My husband is dead."

For a while there was silence, it seemed, though Venera knew abstractly that everyone was shouting, that the news of Margit's sudden departure was spreading like fire through Liris. Eilen and the others were speaking to her, but she couldn't understand anything they said.

Strangely calm, she looked through the rushing people at the one other person who seemed still. He was giving orders at the foot of the stairs to Margit's chambers, putting out his arm to prevent people without firefighting tools from going up, pointing out where to get sand or buckets to those just arriving. His face was impassive; but his gestures were quick and focused.

"What are we going to do?" Odess was literally wringing his hands, something Venera had never actually seen someone do. "Without the botanist, what will happen to the trees? Will Sacrus forgive us for what you did? We could all be killed. Who is going to lead us now?"

Eilen turned to Odess, shaking his shoulder crossly. "Why shouldn't it be Venera?"

"V-Venera?" He looked terrified.

She laughed. "I'm leaving. Right now. Besides, you already have your new botanist." She pointed. "He's been here all along."

Moss looked up from where he was directing the firefighting. He saw Venera, and the perpetually desperate ex-

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pression around his eyes softened a bit. She walked over to him.

As shouts came down the stairs saying that the fire was under control, she laid a hand on the former envoy's arm and smiled at him. "Moss," she said, "I don't want you to be sad anymore."

"I-I'll t-try," he said.

Satisfied, she turned away from the people of Liris. Venera traced the steps Margit had taken only minutes before, pausing only to arm herself in Liris's barracks. She walked up the broad stone steps over which towered row after row of portraits—centuries of botanists, masons, doctors, and scholars, all of whom had been born here, lived here, and died here leaving legacies that might have been known only to a handful of people, but were meaningful nonetheless. She trod carefully patched steps whose outlines were known intimately by those who tended them, past arches and doors that figured as clearly as heroes out of myth in the dreams and ambitions of the people who lived under them—people to whom they were the very world itself.

And on the dark empty roof, cold fresh air blew in from the abandoned lofts of Winter.

She threw back the trapdoor and stalked to the roof's edge. These were the final steps of her old life, she felt. Venera was about to mourn, something she had never done and did not know how to do. She stepped onto a swaying platform and began winching it down, feeling the uncoiling certainty of her husband's death in her gut. It was like a monster shaking itself awake; any moment now it would devour her, and who knew what would happen then? Her only defense was to keep turning the wheel to winch herself down. She focused her eyes on the tall grass that swayed at the foot of Liris, willing it closer.

In the dim light cast by Lesser Spyre, Venera Fanning walked into the wild acres of the disputed territories. She moved aimlessly at first, admiring the glittering lights overhead and the vast arcs of land and forest that swept up and past them.

When she lowered her eyes it was to see the black silhouette of a man separate itself from a grove of trees ahead of her. Venera didn't pause, but turned slightly towards the figure. He came out to meet her, and she nodded to him when he offered his arm for her to lean on.

"I've been waiting for you," said Garth Diamandis.

They walked into the darkness under the trees. □

To be continued.

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Science Fact

Toward a Not-Just-Diamond Age

Stephen L. Gillett, Ph.D.

"The Diamond Age." Not only was it the title of a Neil Stephenson SF novel a few years back, it's even become a cliché, shorthand for the dawning era of nanotechnology.

Of course, we know why: Diamond is the hard, rigid but light form of carbon; and carbon is The Ultimate Nanotechnological Material. It has one of the highest specific strengths—strength-to-mass ratios—known: Four of its six electrons are available for bonding, so the nuclear "dead weight"—the protons and their associated neutrons—is minimized. The ugly word "diamondoid" has even come into vogue to describe molecular frameworks and structures based on the diamond structure.

Diamond, even on its own terms, may be just a bit overblown, though. At least for macroscopic applications, composites based on carbon nanotubes—"buckytubes"—are probably better. They're likely to be just as strong as—even stronger, in applications involving cables or filaments—than diamond, and they're likely to be considerably easier to fabricate.

But they're still carbon, right? Still The Ultimate Material. Once we achieve full-blown—or even partial-blown—nanotechnology, there won't be any reason to use anything else!

Actually, there probably will be. Oh, sure, there's no question things like a skystalk to geosynchronous orbit will be carbon based. Specific strength *is* everything in some applications.

But carbon has some serious disadvantages. For one thing, it *burns*. Particularly when it's in the form of fine particles. Even at ordinary temperatures, aerosols of things like coal dust are explosive. This is one of the many hazards in underground coal mining. Recent research has shown a coal-dust explosion probably also sent the British

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Table 1. Bond Energies, Si and C

	Si		C	
	kJ/mol	aJ	kJ/mol	aJ
-Si	322	0.535	372	0.618
-O	535	0.889	346	0.575
=O	—		808	1.343
-C	372	0.618	335	0.556

Table 1. Important Si and C bond energies. They are given both in kilojoules per mole (kJ/mol) and in attojoules (10^{-18} joules).

liner *Lusitania* to the bottom in 1915. It was torpedoed by a German U-boat, but the ship was ripped open by a much larger explosion some seconds *after* the torpedo impact. Rather than from contraband munitions, then and since a widespread speculation, this subsequent explosion seems to have resulted from coal dust raised in the liner's nearly empty bunkers by the initial concussion.

Applications that envision clouds of free-floating nanobots, such as J. Storrs Hall's "Utility Fog," will *have* to be made out of nonflammable materials. A carbon-based utility fog would be a dandy fuel-air explosive. And that's just one example—flammability is going to be a major concern in lots of other cases, too. As we'll see, inert molecular frameworks that are immune to oxygen are easy to build with other materials than carbon, and those frameworks have a host of potential applications.

But non-flammability is not the end of the story by any means. For all the paeans to carbon, other elements can form frameworks that look to have extraordinary—and extraordinarily useful—physical properties, for nanoelectronics, catalysis, element separation, "programmable" matter, and a host of other applications.

The Not-so-Close Cousin

What about alternatives to carbon, then? Silicon (Si) immediately comes to mind. After all, everyone (or at least everyone who reads *Analog*) knows that silicon is the chemical cousin of carbon, occurring immediately below it in the Periodic Table. That's, of course, also the inspiration for the old chestnut about silicon-based life.

However, the chemistry of silicon and carbon is really quite different, as I've described previously ("Diamond Ether, Nanotechnology, and Venus," Nov. 1999). Elemental Si, to be sure, has the diamond structure, but silicon-silicon bonds are not so strong as carbon-carbon bonds (Table 1), and with the extra mass of the Si atom, the specific strength is much less. Silicon also has little tendency to form the double bonds so characteristic of carbon, whose formation, indeed, largely *defines* the enormous variety of organic chemistry. Because of this, for example, silicon can form no analog of the hexagonal carbon—"graphene"—sheets that make up buckytube walls. The striking contrast in chemistry arises largely from the difference in size of the two atoms. The "orbitals," the places where the unshared electrons responsible for bonding are localized, can overlap a great deal between adjacent carbon atoms to form a second or even a third chemical bond. The silicon atom is simply too big for that to happen.

A more promising idea looks not at sili*con* but sili*cates*, compounds of silicon and oxygen with other elements. The silicon-oxygen bond is strong (Table 1). At ordinary pressures, silicon can form four (single) bonds with surrounding

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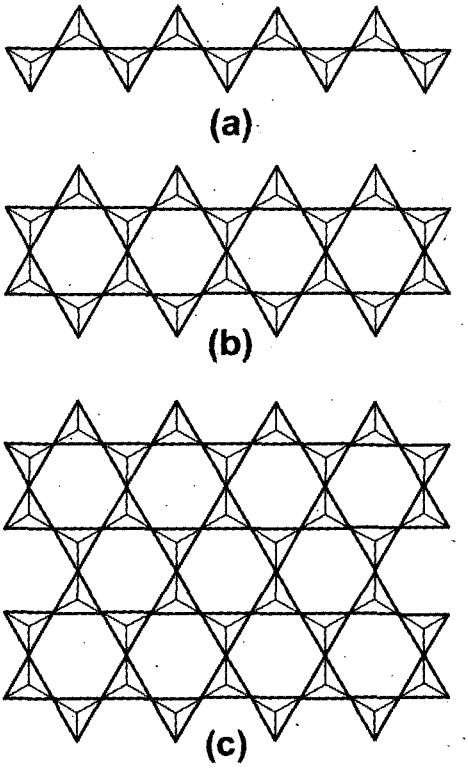

Figure 1. Silicate structures. (a) Chain structure in pyroxenes; on replacing the oxygen at the unshared corner of each tetrahedron with a methyl (CH_3) group, it's also the structure of polydimethylsiloxane ("methyl silicone"). (b) Double chain in amphiboles. The structures in (a) and (b) extend indefinitely both right and left. (c) Sheet structure in mica and clay minerals. This structure extends indefinitely in two dimensions. Individual silicate (SiO_4) tetrahedra are shown diagrammatically; where tetrahedra are joined at a vertex, the oxygen is shared between two tetrahedra.

oxygens to form a tetrahedron, the "silicate tetrahedron," a strong, compact unit that is the fundamental building block of silicate chemistry.

Some silicates, such as the mineral olivine, $(Mg,Fe)_2SiO_4$, contain the isolated SiO_4 tetrahedron. In such minerals it's a negatively charged ion ("anion"), with four extra electrons: SiO_4^{4}. The metal atoms are positive ions ("cations"), each having lost two electrons. The metal cations and silicate anion then stack alternately to make up the structure. The whole business is a so-called "ionic crystal," which sticks together just because of the simple electrostatic attraction between the cations and anions. It's just like a host of other ionic salts like sodium chloride—or better, like other oxyanion salts like sodium sulfate (Na_2SO_4), where the sulfate anion acts like a single unit, too.

If this were all there was to silicates, their chemistry would be pretty dull.

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The real variety comes from the fact that the tetrahedra can share corners to make a disiloxy bond (Si-O-Si), in which an oxygen links two silicons. Although it is single, this bond is not only strong, it's partly *covalent*. That is, it results from a quantum-mechanical blending of the orbitals, not merely from electrostatic attraction between an oxygen anion and a silicon cation. Because of the covalency, the bond is resistant to *shear,* or bending, as well as to extension.

If each tetrahedron shares two corners, a chain structure results. The *pyroxene*[1] minerals have such a structure (Figure 1a), and the remaining negative charges on the chains are canceled by metal ions stacked between the chains. Two common pyroxenes are enstatite, $MgSiO_3$, and diopside, $CaMgSi_2O_6$. Double-chain structures, consisting of two parallel single chains in which every other tetrahedron shares a third oxygen with the adjacent chain, are basic to the *amphiboles,* another widespread group of minerals (Figure 1b). Hornblende is an example of this group.

The *silicones* (or, more properly, "siloxanes") are a technological version of a silicon-oxygen chain structure. In this case, instead of negatively charged chains with intercalated metal ions, organic side groups such as methyl (CH_3) groups are attached to the chains in place of the unshared oxygens. A simple silicone is polydimethylsiloxane, $(CH_3)_2SiO$.

And now you can see one reason silicate backbones might be promising for nanotechnology!

But we don't need to stop there. If three oxygens on *every* tetrahedron are shared, we get an infinite sheet structure. These are also ubiquitous in the natural world, making up the micas and clay minerals. The platy structures of these minerals directly reflect their molecular structure. They split ("cleave") easily along the plane of the sheets. The micas, for example, can be visualized as having a layer of tetrahedra all sitting on a face and sharing all three corners on that face, while the unshared corner sticks up. Under scanning-probe microscopes the layer has a hexagonal pattern that looks a bit like chicken wire (Figure 1c). A corresponding tetrahedral sheet above has all the unshared tetrahedra pointing down, and metal cations between the tetrahedra cancel most of the negative charge. So it's kind of a "sandwich" structure.

There's a bit of negative charge left over, though, and big cations between the "sandwiches" cancel it. They're usually potassium cations in natural minerals, and they tuck into those hexagonal holes.

This plane of weakness, where the potassium cations hold the sheets together, is where the cleavage occurs. In fact, carefully cleaved mica sheets are actually atomically flat over distances of millimeters, even centimeters. That is, the surface of the very same(!) silicate sheet is exposed over macroscopic distances. This extraordinary phenomenon has been exploited in surface science studies for years, and the atomically perfect surfaces are an obvious basis for studies in protonanotechnology. In fact, they're being used a *lot*.

Sheet silicates are also the basis of another bit of protonanotechnology. Those cations-between-the-sheets ("interstitial" cations, to use the formal name) can be swapped out for others to give materials that can't be synthesized any other way. In particular, replacing the potassium ions with big cations like tetrabutylammonium, $(C_4H_9)_4N^+$, leads to so-called "pillared clays." The larger cations hold the sheets farther apart, like pillars. This creates molecular-scale galleries into which other molecules can fit. These now have a big literature largely because many make good catalysts, just as

[1] Pronounced "PEER-ux-een" by geologists and mineralogists, by the way.

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with the zeolites described below.[2]

What happens when we share all four corners of each silicate tetrahedron? We get an infinite three-dimensional (3D) framework whose composition is simply that of silica, silicon dioxide, or SiO_2. Silica occurs in a number of different structures, depending on how the tetrahedra are linked. The most common form is quartz, but there are others (cristobalite, coesite, etc.) One of the most interesting is an artificial form called *silicalite,* in which the structure is so open that it contains channels and tunnels into which other molecules can fit. In fact, it's an aluminum-free zeolite, of which much more anon.

Note the stark contrast of SiO_2 with its chemical cousin, carbon dioxide, CO_2. Sure, the stoichiometry—the ratio of the atoms—is the same, but the structure is vastly different. CO_2 is made of individual molecules, each consisting of two oxygens double-bonded to a carbon in the middle. It is not a 3D structure, at least under ordinary conditions. Silicon, however, can't make those double bonds. So it's a solid 3D framework.

Because of the corner-sharing of silicate tetrahedra ("polymerization," as chemists call it), the chemistry of ordinary rocks eluded chemists and mineralogists until the first half of the twentieth century. Not until X-ray techniques were developed did the structures begin to be worked out, beginning in the 1930s. That's one of the reasons that silicate chemistry is still not well known outside the specialist communities, in fact. The new discoveries didn't start hitting the mineralogy textbooks till after WW II, and they're *still* not well described in many chem texts. (*Ahem,* any textbook writers listening?)

Natural silicate chemistry is made even more complicated by ion substitution. The only thing that really matters with the cations stuck between the negatively charged anions is their size and charge. They don't have to be the same element! So if two metal ions have the same charge and size, you can mix 'n' match them in the crystal. Iron and magnesium, for example, are both common elements, and the Mg^{+2} and Fe^{+2} ions are about the same size. They tend, therefore, to occur in the same minerals—what a geochemist affectionately calls "ferromags." We saw this already above in olivine, $(Mg,Fe)_2SiO_4$. This is also why many minerals tend not to have well-defined chemical formulas, another reason that mineral chemistry was such a puzzle until the first third of the twentieth century.

It also provides some inspiration for nanotechnology, as we'll see.

As I noted a few paragraphs back, if we hook up all four vertices of the tetrahedron we just get silica, SiO_2. It has its uses, of course. Very strong fibers that don't burn are an obvious one, which Goodloe and Oltion used in "Waterworld" (March 1994). In fact, strong, nonflammable structures are an obvious application generally. Silicates, of course, are brittle; consider the effect of dropping a water glass onto a concrete floor! (Ordinary glass is a partly polymerized silicate with no long-range atomic order.) As I've described before ("Near-Term Nanotechnology," Oct. 1998), and has been pointed out repeatedly in the nanotech literature, though, brittle materials are actually far stronger than metals. The problem is that they're vulnerable to catastrophic failure ("Griffith failure") if they're not atomically perfect. Nanotechnological assembly, of course, aspires to that perfection.

[2] This is an example of *chimie douce* (literally "soft chemistry"), which is a burgeoning set of techniques in protonanotechnology. *Chimie douce* implies low-temperature techniques, such as swapping out mobile atoms or ions, that generally leave the overall molecular structure intact. It lets you make compounds that can't be synthesized directly.

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Open silica frameworks could also be handy as "molecular sieves," literally molecule-sized filters for straining certain molecules out of a background of lots of others. In fact, I mentioned the present-day existence of silicalite above, which has such an open framework.

But there's not a whole lot of compositional variety!

There's nothing that says, though, that we just have to put *only* silicon atoms in the linked tetrahedra. Substitution doesn't just apply to the interstitial metal cations. We can stick other atoms into those tetrahedral sites; and when we do so, we can get a lot more variety. And a lot more usefulness.

We can substitute aluminum atoms into a fully linked tetrahedral silicate framework, for example. Since aluminum has one fewer protons than silicon, the framework ends up with an overall electrical charge: one negative for every aluminum atom present. To cancel this charge, we need to stick metal cations into holes in the framework. So we end up with 3D frameworks ("tectosilicates") that aren't *just* silica, and that furthermore can accommodate other cations as well.

Aluminum substitution is ubiquitous in natural silicates because aluminum is the third most abundant element in the crust, after oxygen and silicon themselves. In fact, geochemists refer to "aluminosilicates," combined silicon-aluminum framework minerals. One group of these minerals, the feldspars, are the most abundant chemical compounds in the crust. Potassium feldspar (affectionately called "K-spar" by a couple of generations of students), for example, has the formula $KAlSi_3O_8$. "K" (from German *Kalium*) is, of course, the chemical symbol for potassium. Since the potassium cation has one "plus" charge while aluminum has three, they exactly compensate for the replaced framework silicon.

Feldspars and quartz, the common, stable form of silica, are the characteristic minerals of granite. Since granite-like rocks largely make up the continents, feldspars are hardly unimportant—but even so, they're not the most promising candidates for a nanotechnology.

Other aluminosilicates are much more interesting. These are the zeolites, aluminosilicates with very open frameworks into which other molecules can fit. The name comes from the Greek for "boiling stone," and it was bestowed in the eighteenth (!) century. In natural zeolites, the frameworks contain water in the voids, and when you heat them up the water fizzes out spectacularly.

Zeolites are an excellent example of present protonanotechnology. They're used by the ton for catalysis, particularly in the petrochemical industry. Catalysts, of course, are substances that make a chemical reaction happen more easily. Zeolites can be highly selective catalysts, because only molecules that can fit into the molecular voids will react. In fact, in their sheer specificity they've been compared to biological enzymes!

Another application that seems set to burgeon is their use as "molecular sieves" for separation. They're already extensively used as drying agents, as H_2O is readily taken up in the voids. The zeolite can then be regenerated for further use simply by heating.

A dawning prospect is "ionic conductors" or "solid electrolytes," which are substances that can conduct a flow of cations. Obviously, they must have open structures so that ions can move from point to point! Solid electrolytes will be critical for practical fuel cells. A fuel cell is basically a battery in which both the substance that gives up electrons (is "oxidized"[3]) and the one that accepts electrons (is "reduced") can be continuously replenished. Instead of the reac-

[3] Oxygen is a good electron acceptor—hence the name "oxidation"—but it isn't the only one. There are better oxidizers than oxygen!

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tive metals familiar in ordinary batteries, then, we can—at least in theory—use stuff we're more used to thinking of as "fuels," like methane or alcohols. This would be far more efficient than simply burning them! (Fuel cells don't *have* to use hydrogen. Hydrogen is just the *easiest* with current technology. That's a very different statement!) Like any battery, though, a fuel cell has to have a cation flow within it to compensate for the external electron flow, and solid electrolytes would be ideal. If we could synthesize good ones, anyway.

Another embryonic application of zeolites is as a molecular framework support. Using *chimie douce* techniques new ions, and even clusters of atoms, can be introduced into the zeolite framework. For one example, silver ions can be introduced into a zeolite framework to make promising photocatalysts for synthesizing fuels by splitting water with sunlight (see "Artificial Photosynthesis," April 2005). This combination of silver ions and zeolite framework has vastly different properties from either alone.

Of course, technology isn't restricted to the element substitutions that occur in nature. All sorts of other atoms have been stuck into zeolite frameworks. Boron, phosphorus, iron, gallium, tin, indium, titanium . . . it's a long list. This hasn't been just golly-gee-whiz academic research, either. The big motivator is better catalysts, a market of hundreds of millions of dollars.

In fact, the substitution can become so extensive that there's no silicon left! The rare mineral berlinite, one form of aluminum phosphate ($AlPO_4$), has the same structure as quartz. You can think of berlinite as derived from quartz by replacing silicon atoms alternately by aluminum and phosphorus atoms. Since the charge on the aluminum atom is +3 while that on phosphorus is +5, they exactly compensate for two silicons each with a +4 charge.

Other metal phosphates also make 3D frameworks. Titanium and zirconium, in particular, form 3D framework structures. They've attracted some attention for carrying out separation, but with current "shake and bake" synthesis techniques, the crystals are far too tiny to do all the things we'd like.

But all this leads to considering framework-forming elements besides silicon, which I'll turn to in the next section.

I can't leave this section, though, without a note on the sheer abundance of silicates. They make up most of a rocky planet—they make up most of *rock!* So raw materials are hardly hard to come by. In fact, the leftovers from conventional mining operations—those great piles of unsightly and environmentally obnoxious dirt—are largely silicates.

How do you deal with them? Well, in conventional extractive metallurgy you largely don't. Most ore minerals are more amenable compounds like sulfides and oxides. That's how you ended up with all that silicate waste, in fact, separating out these ore minerals. But in recent years, with the interest in extracting materials from lunar regolith, there's been some research into how you might go about processing silicates.

With great difficulty, in current concepts: Proposed processes require seriously nasty reagents like hydrofluoric acid (HF) or free elemental fluorine to break up silicates. Fluorine compounds are capable of displacing oxygen from silicates; not much else is. (HF is used to etch glass.) And having tons of fluorine or HF lying around would be a profound hazard for a lunar base.

Remarkably, however, there *are* alternatives to HF. Certain organic(!) reagents are capable of dissolving silicates. An example is *catechol* (1-2 dihydroxybenzene, Figure 2). The two oxygen atoms are just the right distance apart to glom onto a silicon atom, and three catechols fit nicely around the atom. Ethylene glycol, $C_2H_4(OH)_2$, better known as the active ingredient in antifreeze, is also capa-

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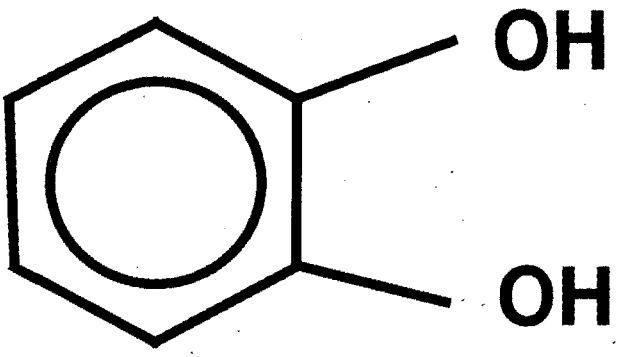

Figure 2. Catechol. The spacing between the OH groups is well matched to the size needed to "grab" a silicon atom.

ble of reacting with silicates. An alkaline "cocktail" containing ethylene glycol can even dissolve beach sand.

"Digesting" silicate raw materials with such reagents is already being investigated for zeolite synthesis. Another driver is "sol-gel" applications, in which a suspension of nanoparticles (a "sol") is condensed into a gelatinous mass (a "gel") and thence into a low-temperature glass. It's really another example of *chimie douce,* because by working at low temperatures—even in aqueous solution!—it lets you synthesize structures that can't be obtained by melting, which of course is the usual way to get a glass.

Using such processing to get nanotechnological raw materials instead scarcely seems a big step.

Electrons, Bronzes, and Tungsten

Tungsten is much better known as a tough, hard, high-melting metal, the material of lightbulb filaments and high-performance alloys—"tungsten steel." In fact, it was so important in WW II that tungsten (chemical symbol "W," from German *Wolfram*, by the way) mining was heavily subsidized by Uncle Sam.[4]

Future nano-engineers, though, will regard those properties as quaint. They will be much more interested in the fact that tungsten can build molecular frameworks with oxygen that are even more versatile than silicon's.

Why are they not just an exotic (and expensive) variation on a more prosaic oxide molecular framework? We have to look at the electronic structure of tungsten to see why. Tungsten is a "transition metal," one of the elements in the part of the Periodic Table where the *d* electron shell is being filled. Most of these elements (and yes, they're all metals) have two electrons in the outer *s*

[4] Tungsten prospects dot the American West; if you see a pit dug out at the contact between a granite and a limestone, it's most probably for tungsten. The main ore mineral for tungsten is scheelite, "calcium tungstate," $CaWO_4$. It forms when tungsten-bearing fluids come off the cooling granite to react with calcium from the limestone. Scheelite is fluorescent in ultraviolet (UV) light: Tungsten prospectors traditionally go out at night and shine UV lights on the ground!

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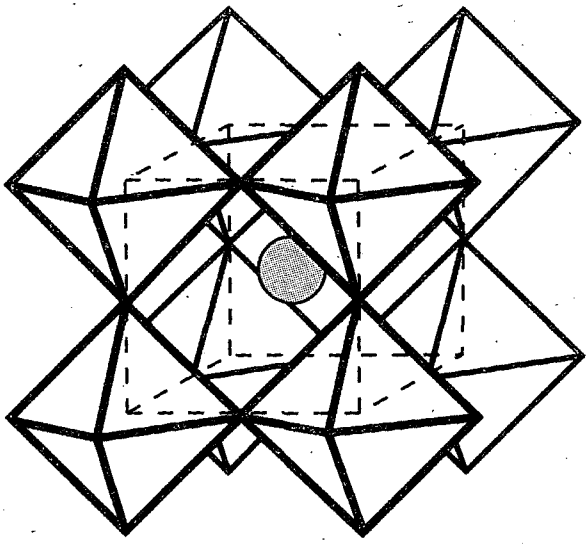

Figure 3. Perovskite structure. An oxygen atom lies at each vertex shared between the octahedra. In WO_3, a tungsten atom lies at the center of each octahedron (positions connected by the dashed cube), while the large site (the shaded circle) between the octahedra is empty. In tungsten bronzes, though, some of the large sites are occupied by the additional metal atoms. (Note: In WO_3 and many other perovskites, the perfect cubic symmetry is distorted.)

electron shell[5], and those always participate in chemical bonding. One or more of the *d* electrons may also participate in bonding, too, though, depending on the chemical environment.

Tungsten provides an excellent example. All oxidation states of tungsten from +2 (no *d* electrons involved) to +6 (all 4 *d* electrons involved) are known in one compound or another.

Carbon, silicon, aluminum, phosphorus, boron, and so on, however, are all "main group" elements. Usually, the *s* and *p* electron shells are used in bonding, and all at once. For heavier main group elements, there are often different oxidation states separated by *two* electrons, as (say) with arsenic, which has +3 and +5 oxidation states. But different oxidation states separated by just one electron don't exist (at ordinary temperatures, anyway[6]). Of course, I mentioned that transition metals such as iron have been substituted into zeolite frameworks, but only as isolated atoms. They don't make up the whole structure, and they don't change its electronic properties appreciably.

Let's look at tungsten trioxide, WO_3, a light green, typically nonmetallic oxide. It's based on what crystal chemists call the *perovskite* structure (Figure 3),

[5] The exceptions are copper, silver, and gold, which have only one *s* electron. Instead of having nine electrons in the *d* shell and two in the *s* shell, they have a full *d* shell of 10 electrons. This single, outer electron, by the way, is why these metals are such good electrical conductors.

[6] Things like aluminum monoxide, AlO, where aluminum has a +2 oxidation state instead of its normal +3, exist in places like stellar atmospheres.

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which is named after (yes!) the mineral perovskite, $CaTiO_3$.[7] Inside each octahedron is a tungsten atom, while oxygen atoms lie at the corners. Note that each oxygen is shared. WO_3 is a wide-bandgap semiconductor. That means it contains a lower energy "valence band" containing all the electrons. Then there's an energy gap between this band and the higher-energy "conduction band," which is empty. (These bands result from blending all the orbitals on the individual atoms.) Because the bandgap is "wide," it's almost an insulator, in fact. Few electrons have enough energy to jump up to the conduction band. That's why it looks like such a typical non-metallic compound.

By a variety of methods, though, you can synthesize a compound that's *almost* tungsten trioxide, except that it has a small (and varying) amount of sodium (Na) in it. Its formula varies from about $Na_{0.32}WO_3$ to $Na_{0.93}WO_3$.

And it looks nothing like tungsten trioxide. It looks metallic, in fact, shiny and golden colored, although it's still brittle. It's even a good electrical conductor!

This was the first example of what are now called tungsten *bronzes*, because of the luster and color of this prototype. "Bronzes" have now been synthesized with many other elements in place of sodium: other alkali metals (potassium, lithium, rubidium), copper, silver, thallium, rare-earth elements . . . Although not all are bronze-colored, they all have this curious combination of metallic luster and conductivity with a brittle, non-metallic texture.

What's going on?

Modern studies by X-ray diffraction have shown that these bronzes basically consist of a WO_3 structure in which some of the big open sites are filled with the other metal atoms. Those atoms are cations, so to keep charge balance, some of the tungsten atoms are now in the +5 oxidation state. That means there's now an extra electron kicking around in the crystal, and it has to go into the conduction band, since the valence band is full. There it's free to travel, which yields typical metallic behavior.

So just by sticking a few extra atoms into this structure, we've changed it from a semiconductor to a metallic conductor. You can't do that with a carbon or silicate structure!

These oxide "metals" are already finding protonanotechnological applications. The energy it takes to remove an electron from a bronze (the "work function," as physicists say) turns out to be a very strong function of its chemical environment. This makes them valuable as exquisitely sensitive chemical sensors.

There's more, though. What if we can swap ions in and out of the WO_3 structure on command? That would shift it from the metal-like bronze form to a near-insulator. It turns out we can, at least to some degree. Make a tungsten trioxide film on an electrode, stick it in an acidic solution, and apply a negative potential to it. Hydrogen ions released by the acid, which are very small, can be drawn into WO_3, upon which it will turn shiny and bronze-like. This even works with the larger (though still small) lithium ion.

Reversible bronze formation, driven by an electric potential, is one basis of so-called "electrochromic" systems: They change color on application of an electric field. In this case, the material changes from transparent to reflective. An SF cliché is windows that can be "opaqued" on command. ("Window, dark!") We now see how to do that, at least conceptually. Use a "sandwich" consisting of a thin layer of WO_3 over a thin layer containing mobile lithium ion on top of the glass. Application of a potential to the WO_3 then turns it into a re-

[7] Which indeed has this structure. The titanium atoms are in the centers of the octahedra, while the big calcium cations sit in the big holes.

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flective layer. (Of course, the web of invisibly thin wiring needed to provide the potential remains a bit of an engineering challenge at present.) Electrochromic materials have also been proposed for information storage, and seem particularly appropriate for light-based "optronic" systems, if they ever prove practical.

Electrochromic systems provide one approach to *self*-darkening windows, too. Put a nano-thin layer of transparent oxide semiconductor atop the WO_3 layer. Absorption of invisible ultraviolet light excites electrons in *that* semiconductor up into the conduction band, where they apply the negative potential to the WO_3. This is an example of a nanotechnological "photochromic" system, a system that changes color on being illuminated.

Of course, now that we're again talking about moving ions in and out of a molecular framework, solid electrolytes become another obvious application. Even extraction of ions from solution for purification or desalination is a possibility. It's yet another possible "switchable" molecular separator (see "Pollution, Solutions, Elution—and Nanotechnology," Jan-Feb. 2006.)

Other metals, too, have now been shown to form "bronze-like" compounds. As you might expect, molybdenum—the element above tungsten in the Periodic Table—forms bronzes, too. But we can now even speak of "titanium bronzes" and "vanadium bronzes" and "tantalum bronzes" and so on. In detail, the structures aren't the same as the tungsten bronzes, but they're all 3D frameworks with big holes in which "extraneous" cations reside, and they all have metallic properties. Furthermore, as we've seen for tungsten, most—but not all—of the framework metal atoms are in their highest oxidation state.

Why do just these metals form bronzes? They're all "early" transition metals—that is, they have relatively few *d* electrons. That's necessary so that the atom has lost all its *d* electrons in the highest oxidation state. If there are too many *d* electrons, they can't *all* be lost—it simply costs too much energy. And the remaining electrons get in the way. They take up orbitals that could otherwise be used for bonding. And yet, even having lost all its electrons, the atom's orbitals still have to extend out enough that they can blend into a valence band. For example, chromium (Cr), the lightest member of the tungsten group, does *not* form bronzes. In its highest oxidation state it forms compact molecular structures instead. The smaller Cr atom just holds onto the electrons too tightly.

Between the sheets . . .

I mentioned the micas and clays above—silicate sheet structures with an overall negative charge held together weakly with big cations like potassium. Even more strikingly, it turns out that certain metal oxides can make sheet structures with an overall *positive* charge, and the sheets are held together with anions—nearly always carbonate ($CO_3^=$), in natural systems. These "layered double hydroxides" (LDHs) generally have the generic formula $X_6Y_2(OH)_{16}CO_3.4H_2O$, where X is a metal in the +2 oxidation state (magnesium, iron, nickel, and so forth), and Y is a +3 metal (aluminum, iron, chromium, manganese, etc.). Note the metals aren't necessarily transition metals, although they can be. The prototype member is hydrotalcite, $Mg_6Al_2(OH)_{16}CO_3.4H_2O$. A very interesting member is "green rust," $Fe_6Fe_2(OH)_{16}CO_3.4H_2O$, which contains iron (Fe) in both its +2 and +3 oxidation states. It's a common corrosion product in weakly oxidizing environments, but turns into ordinary orange rust very quickly on direct exposure to air. For this reason its very existence wasn't even well documented until fairly recently.

It's more difficult, but just as the interstitial cations in silicate clays can be

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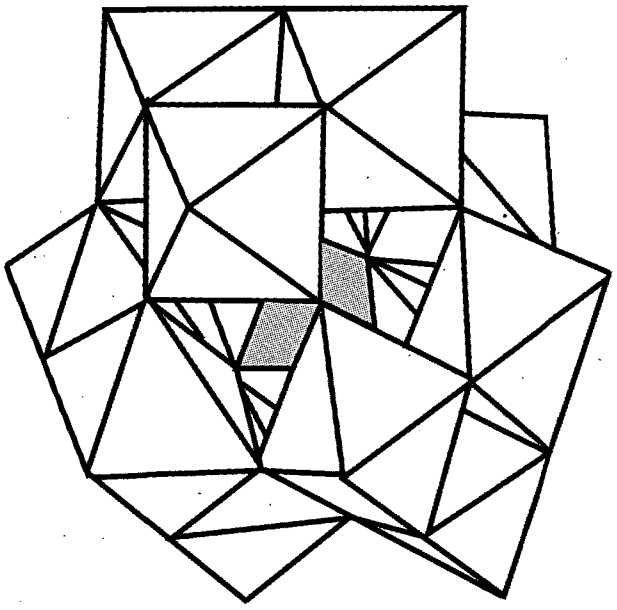

Figure 4. The Keggin ion. Four sets of three linked octahedra surround a tetrahedral ion, shown by the shading in the middle. The octahedra each have a tungsten atom in the center and an oxygen atom at each vertex. The oxygen atom is shared where vertices are linked.

swapped out, so can the carbonate *anion* in LDHs to make a completely different sort of pillared clay. Once again the economic driver is the search for better catalysts—one of the best examples of protonanotechnology.

And a particularly interesting class of "pillaring" anions is *polyoxometalates*, which gives me an excuse to turn back to tungsten. . . .

I Got Them Heteropoly Blues . . .

Tungsten and some of the other early transition metals also make interesting molecular structures that fall quite a bit short of the 3D frameworks I talked about above. For years it's been known that tungsten and oxygen will form "polytungstate" ions in solution, such as "paratungstate Z," $W_{12}O_{41}^{-10}$. More intriguingly, "heteropolytungstate" ions containing a set of WO_6 octahedra arranged about one or more other cations (the "heteroatom") are surprisingly easy to synthesize and surprisingly stable once you do. An example is the Keggin structure (Figure 4), $XW_{12}O_{40}^{-3}$, which contains four sets of three linked WO_6 octahedra arranged around a heteroatom in tetrahedral coordination ("X" in the formula). X can be silicon, phosphorus, iron, cerium, titanium . . . a remarkable assortment of different cations.

Just as with metal-oxygen frameworks, too, other early transition metals can form similar anions, now generically termed "polyoxometalates." As with tungsten, many are stable in aqueous solution over a wide range of conditions.

These anions represent an extraordinary degree of self-organization: literally *dozens* of atoms spontaneously assembled into kazillions of uniform units. Carbon doesn't do that, especially out of aqueous solution. It's hardly surprising

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that polyoxometalates are already getting much interest as molecular building blocks. The interest isn't just theoretical, either; actual molecular structures based on polyoxometalates have been synthesized, as with the pillared LDHs I described above.

Polytungstates and heteropolytungstates, and some other polyoxometalates as well, are also easy to reduce—that is, they accept additional electrons easily. When they do, the extra electron is "smeared" over the whole structure ("delocalized," in the language of quantum mechanics). This makes the anion absorb visible light, so solutions containing the reduced anions go from colorless to blue. Traditionally, these have been called "tungsten blues" or "heteropoly blues," and they were a puzzle before the development of quantum-mechanical models of chemical behavior.

Why are blues important? Well, they show another way in which you can change the electronic properties, and hence the optical properties, drastically with minimal effort. In fact, polyoxometalates prove to be excellent photocatalysts and may soon find use in photochemical water splitting (see "Artificial Photosynthesis," April 2005).

Why "oxide" frameworks, anyway?

What is it about oxygen? I've only talked about oxygen in forming nanotechnological frameworks with other elements. Is it also some sort of Ultimate Element, as carbon is supposed to be?

There are some good reasons for focusing on oxygen, besides its sheer abundance. Oxygen has *two* bonds, which is the minimum for forming a "framework." The halogens—fluorine, chlorine, and so on—although also powerful oxidizing agents, can't form a framework because they can only accept one electron.

Sulfur, as oxygen's second row homolog, is an obvious alternative. I've already noted, though, that second-row elements tend not to be too much like their first-row congeners, and here's another example. Although sulfur does form lots of compounds, it's not very good at forming *framework* compounds—i.e., structures with open voids. A further practical problem is that sulfides oxidize very easily—if there's oxygen around, sulfur and metals react with it!

On the other hand, oxidizing elements that accept more than two electrons tend not to "want" to form extended structures. But having said that, it's recently been shown that nitrogen, which can accept three electrons, can be a bridging element like oxygen. "Nitridosilicates" have been synthesized, and even nitridomolybdates and nitridotungstates. Since the nitrogen atom forms three links rather than two, it also can potentially form complicated frameworks indeed.

Whether they'll find any nanotechnological (or other) application is left to the future to find out.

Toward the Diamond-and-Other-Things Age

The advent of nanotechnology does *not* mean the rest of the Periodic Table becomes irrelevant! It doesn't even mean that some traditional elements won't stay in demand.

It just means they'll be used for different things. ■

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Trucks

Amy Bechtel

What's "hard" or "easy" depends on who's judging. . . .

Fourteen hundred and seventy-six, Joanna thought automatically, watching frozen peas bounce across the kitchen floor. Some of them disappeared under the stove, where they would be virtually impossible to retrieve. Joanna sighed, holding the empty pea bag in her hands. It really wasn't fair for it to split when all she'd done was lift it out of the freezer.

Joanna's six-year-old son Ryan had been watching the peas fall too. "Ryan?" she said hopefully. "How many?"

Ryan looked bewildered. He gazed across the kitchen floor, as overwhelmed as if she'd asked him to memorize the dictionary.

"Never mind, sweetie," Joanna said sadly. Ryan picked up his toy truck and hurried out of range of the peas, and ten-year-old Lauren skipped into the kitchen.

"Ha, ha!" Lauren said. "No peas tonight! No peas for dinner." She scanned the floor quickly and said, "Fourteen hundred and fifty-nine." She was seventeen short, of course, having missed seeing the peas that had rolled under the stove. Joanna studied her face carefully. Eyes crinkled, thirty-seven percent; right side of mouth up seven degrees, left side up eight degrees, wrinkles on the lateral side of each eye. Happy, laughing.

"Why don't you help me pick these up, Lauren?" Joanna said, watching ruefully as the parameters of Lauren's face changed dramatically. A moment of calculation later, Joanna deduced that her daughter was frowning.

"I didn't spill them," Lauren said.

"No, you didn't, but don't you think it would be nice if you helped me anyway?"

A pause, while Lauren studied Joanna's face, obviously trying to decide if this was an order or not. But Lauren wasn't that far along in school yet, and she still had trouble calculating even the most obvious expressions. She lifted her

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shoulders (sixteen percent left, twelve percent right), raised her eyebrows, and started picking up peas. Resignation, Joanna calculated. But at least Lauren was helping with the peas.

When they'd gathered eight hundred and ninety-two of them, Lauren said, "Mom? Why does Ryan have to go to that special class?"

Joanna closed her eyes. Her own little boy was in special education, completely unable to manage a normal first-grade class. It was a hard thing to bear. She said, "Because he doesn't learn as fast as you do, honey."

"The other kids call him names. They say he's stupid. They say I'm stupid too, because I'm his sister."

"Well, those other kids are just being mean, aren't they? Besides that, they're wrong. You're a very smart girl. And Ryan isn't stupid. He's just slow."

"Are you sure I'm smart?" Lauren shoveled her last handful of peas into the trash, her expression changing again. Joanna quickly evaluated the new movements and angles of her face. Anxiety.

"Yes, I'm sure."

"Fifth grade is hard, though. We already have lots of homework, and it's only the first week. Can you help me with it?"

"Of course, honey. As soon as I get dinner on."

Lauren's face changed. A smile. "Dinner with no peas!"

Half an hour later Joanna was at the kitchen table by Lauren's side, looking over her homework. Lauren had sailed through her physics and calculus, but she was struggling with her expressions assignment. This workpaper was all faces, some of the expressions much more subtle than Joanna would have expected to find assigned to fifth graders. Lauren was doing well with the calculations, but kept getting lost when it came to the final analysis.

"All right," Joanna said. "Now you have the numbers for the eyebrows, the eyes, and the mouth. What does it all add up to?"

"Um." Lauren opened her textbook, looking hopelessly at the columns of numbers. "I don't know. Why is it so hard?"

"Because you have to memorize what expression goes with what range of numbers, and there's a lot of them to learn. You're doing fine, Lauren. Everybody has trouble with this part."

"Vroom," Ryan said. He rolled a toy truck across Lauren's homework, peered at the problem she was working on, and pointed at the face. "Scared," he said.

Joanna stared at him. The face *was* scared. How had he guessed?

"Don't be silly, Ryan," Lauren said. "This is fifth grade homework. It's way too hard for you."

Curiously, Joanna turned the page and pointed at another face. "What's this one, Ryan?"

"Happy." He scanned the rest of the page and his lips moved upward, smiling, reflecting the face he had just solved. He pointed to the next face, and the next, and the next. "Sad, angry, sleepy, sad, happy."

Joanna laughed. No one could calculate faces that quickly, certainly not poor little Ryan. But then she started to work on the faces, and she felt her own face changing as she solved each one. Sad. Angry. Sleepy. Sad. Happy. Ryan had correctly named every one.

Ryan pointed at her, said, "Surprised," and picked up his toy truck again.

"Ryan, you're bothering me. Go somewhere else and play," Lauren said. "Mom, I can't find it in the book. Mom? I need help."

But Joanna sat very still for a moment longer, her mind racing, unable to believe what she had just seen. No one could do what Ryan had just done, no one but an utter genius. But Ryan couldn't even count, and the school had put him into special education classes. Deep

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in her heart she didn't believe he belonged there, but even so they were right that he would never be able to manage a normal class. First grade meant elementary algebra and geometry, and even at recess the other kids would be playing with square roots and primes.

But he'd figured out every single face correctly. In a flash, as if he hadn't had to calculate at all. What was going on in her little boy's mind?

That night in bed, Joanna murmured the news to her husband David.

"He did what?" David said.

"He did all of Lauren's expressions homework. In seconds. He knew what every face meant."

There was a silence while David shifted in bed and adjusted his pillow. "Joanna, honey," he said, "I know you're really upset about Ryan going into special education, but—"

"Yes, I am, but that doesn't have anything to do with this."

David sighed. "Oh, Joanna. He must have been guessing."

"But he couldn't have been. If he was guessing, he wouldn't have been right every time."

David shook his head. "It's impossible, honey," he said gently and turned over.

"It is not," Joanna whispered, but David was already asleep. Joanna turned away from him and lay awake for a long time in the dark.

When Joanna picked up the children at school the next day, Lauren's voice was high and strident from the back seat. Excitement, Joanna decided.

"We have to write a paper," Lauren said, "about what we're going to be when we grow up. I'm going to be a spaceship computer and navigate all the way to Mars."

Joanna felt her face move into a smile. "That's a good ambition, Lauren."

"I know. What about you, Ryan? What do you want to be when you grow up?"

Silence from the back seat. Joanna pulled out into traffic, headed for the grocery store.

"Come on, Ryan," Lauren said. "You must want to be something when you grow up."

"I'm not going to be anything," Ryan muttered. "I'm too stupid."

Moisture filled Joanna's eyes, and they stung. Ryan had never said anything like that before he'd started school. She rubbed her eyes as she drove past a spindly tree that had recently been planted in the median. It only had seven hundred and eighty-three leaves left, and it looked wilted; it probably wasn't going to survive there.

"You are not either stupid," Lauren said. "You're just slow. And you have to be something when you grow up. Why don't you be a spaceship computer, like me?"

"No," Ryan said. "I can't count."

What *would* Ryan do when he grew up? What happened to special-needs children when they became special-needs adults? Even if she wasn't imagining it, even if he *was* a genius with faces, what good would that do him in the long run?

At the grocery store, she had an inspiration. "Ryan," she said. "That man over there by the bananas. What's his expression?"

"I know, I know," Ryan said. "Bored."

"And how about that woman by the bread?"

"That one, in the yellow pants? She's angry."

After several more rounds she was certain of it. Ryan was a genius with expression, not only of faces, but of voices and body positions as well. Somehow he took in the whole person at a glance and knew the answer without making a single calculation. He could instantly see expressions as easily as a normal person could instantly count the number of peas falling from a split bag.

Joanna was in a daze when she

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reached the checkout counter, and she agreed without thinking when Lauren and Ryan asked for a candy bar each. The teenage checkout clerk chewed gum as she tallied Joanna's purchases.

". . . two ninety-eight, four ninety-nine, eleven ninety-nine, one twenty-five, one thirty-five, discount two twenty-three, tax six seventy-six, total ninety-eight thirty-two," the checker said all in one breath, and cracked her gum.

Joanna frowned, pulling out her checkbook. The teenager's brows drew together: confusion.

"What's that expression, ma'am?" the teenager asked. "It's one of the bad ones, isn't it?"

"It's disapproval," Joanna said. "It's rude to crack your gum when you're taking care of customers. I'm surprised your manager lets you chew gum at all."

"Oh." The clerk lifted her shoulders. "I forgot I had the gum. And I have, like, trouble reading expressions."

"Maybe you should work a bit harder in school," Joanna suggested.

"I don't like school," the clerk said, her eyes lowered, her mouth turned down. "I'm slow, see."

"Oh," Joanna said, suddenly and acutely reminded of Ryan. "I'm very sorry to hear that."

She pulled up to the bank next, to make a deposit. There were twenty-nine people waiting in the lobby and the lines were long, but the tellers were generally quick. Lauren was still trying to interest Ryan in something to do when he grew up.

"A bank teller," she suggested, pointing to the counter. "A security guard. Look, see? You could have a gun."

"Maybe," Ryan said, looking at the security guard, and Joanna thought she could analyze a trace of interest in his voice. More people joined the lines. Two men moved to stand behind Joanna, shifting from foot to foot. Their expressions were odd; she couldn't quite figure them out. Nervous, but there was something else as well. "Ryan," she whispered, hoping he remembered the game from the grocery store.

Ryan looked at the two men and his own face changed. His eyes widened, his mouth opened; twenty-nine percent, twenty-seven. Frightened. "Let's go home, Mom," he said.

"In a little bit, Ryan. See? We're almost to the counter."

"I want to go home now."

"Ryan—"

Ryan pulled away from her, made a wide circle around the two men, and headed for the door. "Ryan! You come back here right now!" She ran after the little boy, with Lauren at her heels, and caught up with him at the door.

"Please, Mom, let's go. Those men are scary. Let's go. Please."

She almost dragged him back into line, to teach him a lesson about running off. But he had looked at the men's faces, and he could read people at a glance, and he was more frightened than she had ever seen him. She took his hand and went out the door, and Lauren followed them.

"Mom, what are we doing?" Lauren asked. "We never got up to the teller. Mom?"

"I've changed my mind," Joanna said. "We're going to go home now."

Joanna watched the news that night after the children were in bed. The top story was about an armed robbery at the local bank, in which customers had been terrorized and two men had escaped with a large amount of cash. Joanna recognized them in the blurry picture from the security camera.

She decided not to say anything to David. He wouldn't believe her, and he would learn the truth soon enough just by being around Ryan. What should she do now with her little boy? Suddenly she saw all sorts of futures for him. He could be an interpreter for those who could not read expressions well. He

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could be a security guard who could see potential problems coming. He could be anything, as long as it had to do with people and not numbers.

But if only he could learn something about numbers, oh, how that would help him in the world. If only he could *see* the numbers, like everyone else did. But he couldn't, no more than she could *see* a face. She had to break down expressions into parts, analyze each one, add them together. Was there some way to do that with numbers?

Joanna turned off the television and sighed. You could break numbers down into primes, of course. Most little kids loved doing that, but Ryan had always been bewildered by the game. Or you could break down a total into its parts, like a grocery sum divided into the amounts due for bread, milk, and bananas. But Ryan would never understand that either. He needed something simpler. What was simpler than a grocery sum?

Disconsolately, Joanna got up and began to straighten the living room. Lauren had left her essay on the coffee table, and Ryan's toy trucks were scattered all over the carpet. Joanna put the essay by Lauren's backpack and then went to get the trucks. She picked up one in each hand, then transferred both to one hand so she could pick up another one. Then she froze, staring down at her hand.

"Mom?" Ryan was standing in the door to the hall.

"What are you doing up, Ryan?"

"I forgot my trucks."

"Yes, you did." Joanna held up the two in her hand. "How many, Ryan?"

He stiffened. "I don't know. I can't count. I'm stupid."

And you're never going back to that school, Joanna thought, *if that's all you've learned there*. "You can't count the way other people do," she said, "but I'll bet you can learn another way."

"What other way?" he said warily.

One truck and one truck is two trucks. He could learn that, and he could learn each tiny progression thereafter; she was sure of it. It was going to be terribly awkward, terribly slow; it would take years for Ryan to learn numbers in this strange and convoluted manner, and he would still never be able to *see* numbers the way a normal person could.

But it had taken Joanna years to learn expressions, hadn't it? And she would never be able to *see* expressions the way Ryan did.

She put a truck on the floor in front of Ryan. "One truck," she said. ■

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Individuals don't react
to global tragedies,
but to personal ones...

Misquoting the Moon

David Bartell

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Illustration by Nicholas Jainschigg

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Asteroid, schmasteroid. Just give me a big gun, and I'll blast that Big Bastard.

Ted tickled the crosshairs over a rough and undulating gray surface, waiting for the moment to feel right. Each deep crease was tempting, a potential fault where a projectile cleaving to its depths could blow the whole beast apart.

Magnified in his scope, the elephant's forehead did look a lot like an asteroid. It turned its head to profile. Better a brain shot from the side because the cross-section is bigger, and it meant that it wasn't charging you, like Big Bastard. Aim for that crease under the ear. . . . *There!*

He pulled the trigger.

The elephants were going to go extinct anyway.

The double-barreled rifle punched Ted's shoulder with a butt like brass knuckles and a bark to match. He felt more pain than the elephant did as she dropped like a sack of lead potatoes. She wouldn't even feel the five tons of knockdown power from the automatic 900 Nitro Express. A torus of yellow dust rolled away from her and broke into the windless air of once-protected Etosha Park, like a lazy smoke ring.

"That was the matriarch," said Hendrik, Ted's guide, breaking their silence with a thick Afrikaans accent. "The rest will not know what to do."

"My plan exactly."

Hendrik smiled grimly, digging furrows about his mouth. He did not show his age when his face was at rest; his freckled, cinnamon skin was taut until an emotion disturbed it. Then he had five wrinkles for every one of Ted's, and they squeezed his wide nose. "It is kinder to kill the entire family all at once."

The other elephants—eight females and two calves—bellowed and bolted, mostly away from Ted and Hendrik. In the days when there were still hundred-pound tusks to be had, one kill was enough.

Things were different now.

Switching to his custom-made rifle, Ted picked off three more of the gals before they made the scrubby trees at the far side of the water pan. Two of the fallen still moved, but he would put them out of their misery soon enough.

His ears rang and the dust choked. "Sorry, old girls. I would have liked to take you with me."

"No Noah's Ark."

"'Fraid not." Ted did not put much faith in the DNA banks on the far side of the Moon. And there was no provision for wild animals of any kind. They'd be very lucky just to keep the humans alive indefinitely. Nearly all of the fauna on the Moon was there for that purpose. With great sorrow, the others were marooned in their natural habitats. "Not even starfish shuttles are big enough for elephants."

The oft-repeated allegory about starfish popped into his head:

Two men on a beach, watching millions of beached starfish slowly dying. One man begins throwing them back into the sea. "You can't save them all," his friend objects. "No, but I can save this one," says the first, tossing a starfish into the surf. "And this one. And this one, and this one. . . ."

That's how Ted Hathaway felt about culling elephants; he did not enjoy it. Travis *had* to shoot Old Yeller. Once he made up his mind to do it, he didn't think about it. Like Hendrik, he didn't ask any more questions, because he would not like the answers. The skyrocketing ivory trade was the only way he could raise enough money to save a particular part of his own species.

Ka-chow! Ka-chow! Quick mercy.

"I can't shoot you all," Ted said as he fired. "But I can shoot you . . . and you . . . and you . . . and *you*. . . ."

Each shot left ringing echoes in his ears. The asteroid was coming, but the gentle giants would not die forgotten. He would share their moment of loss now and remember it always. If only

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stopping Big Bastard was as easy as shooting elephants.

Africans of several ethnicities appeared in dusty, battered vehicles—a Volvo and two combis—to help skin the carcasses. A friend of Hendrik's came with a lorry, which would bring some of the meat back to their families. Ted and Hendrik left them on foot, tracking one injured cow into the bush.

The Sun set rapidly so near the equator, dropping straight down as if of fatigue from baking the salt pans all day, and the lack of clouds made it a brief, orange event. They made camp, ate, and settled by the fire. A distant yelp and then a roar caused Ted to squint into the night, but Hendrik kept his gaze on the retiring flames. The guide seemed as unaffected by the impending catastrophe as the wildlife was. A lion had just made a kill. What else was it supposed to do?

"Why did you come back?" Hendrik said. "You were safe on the Moon."

"Maybe. There aren't any lions up there, but I wouldn't call it safe. They say bits of Big Bastard could pummel the Moon, or that it will send chunks of Earth that way. None of us may escape this one. And the strongholds aren't as strong as you might think either. They really haven't solved all the problems of self-sufficient biospheres."

"But here is certain death. Why come back? For the elephants?"

Ted had to think about answering that one. "They're not like other animals. When you shoot an elephant, it's like shooting a dog or a horse. Something inside you dies with them. But something else comes alive. I just wanted one last look at the way things used to be."

"I understand you."

Ted laughed. Everyone else had always said just the opposite. Even his biographer had surrendered.

"You're a very lucky man," Hendrik said. "You have a rare place in the colonies, and you are still rich enough to come back for one last look around."

Ted pulled a pipe from his jacket, a bent Rhodesian, supposedly designed by Alfred Dunhill, if not Cecil Rhodes himself. He tamped a Turkish blend of latakia into its bowl. One last chance to smoke.

"Yeah, I'm lucky. I'm lucky that ivory is in high demand now, and that I know how to get it."

"Why is it in demand?"

Ted watched a tentacle of smoke twist up from his pipe like the shriveled ghost of a very old idea. "Superstition," he said. "When you want something rare, it stands to reason that to get it, you have to buy it with something equally rare. There are folks who think that ivory is good luck, and that it will somehow get them a spot on the Moon."

Hendrik looked disappointed. "That's foolishness."

"Mmm," Ted agreed, puffing at his pipe. "They call it the Lunar Lottery, but it's become lunacy, if you ask me."

"Then why do you sell the ivory? You don't need the money."

"Ah, but I do. Dolores is the reason why."

"She left you years ago, my friend."

"If I can purchase a double occupancy upgrade, she'll have a damn good reason to come back now, won't she?"

The gibbous Moon rose, and the shimmering Milky Way shied from it. Ted looked for his crater home but could not make it out.

Hendrik tipped his head back, watching the Moon over his nose, mouth agape—not with wonder, but trying to catch a memory. "Moon buggy!" he said. "I remember that from some old documentary. Do you have a moon buggy?"

"Bully for you!" Ted smiled. "Not yet, but you have a good idea at that."

He inhaled the smoke from the fire. Mopane, spicier than the usual camelthorn acacia—more like mesquite—but more subtle, evoking memories of times and places both good and bad. The odor mixed with his tobacco, and he held it in his nose, eyes

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closed, to seal the memory.

The white dot of a satellite snuck across the sky, from south to north. Must be polar, he thought. Or a starfish tender. Or a spider-sat spinning a sensor web with which to measure every aspect of asteroid impact. What good would data minutiae do if there wasn't any planet left to benefit? The money should have been spent on another lunar colony. Hell, they could have even built some kind of zoo on the Moon for the damned pachyderms.

From what Ted understood, they had spent fifty trillion dollars trying to deflect Big Bastard. The gravity tugs and nukes couldn't keep Big Bastard out of the deadly keyhole the way they had with Apophis in 2037. That "little bastard" didn't take much to be thrown off by the fraction of a degree needed to steer it clear. A little elbow-to-elbow sashay with the Earth scooted it into a stable orbit around Mars, all as planned. It was brilliant, a crowning achievement for humanity, inspiring renewed respect for the abilities of the species.

But gravity tugs were just too small to exert sufficient force on Big Bastard. A series of attempts were made to use tugs to deflect other asteroids near Big Bastard so that they would in turn draw the target off. Unfortunately, like rodeo clowns failing to distract a bucking bull, they could not keep the horns from goring their victim. Mother Earth was no help either; she was reeling the rock in like a moth that had lassoed her flame. One theory even claimed that Big Bastard had impacted Earth before, ages ago, the result being the formation of the Moon. Ted believed it. Big Bastard was like an old flame, a man-eater; having once tasted the flesh of the Earth, it lusted for more.

The lunar colonies were already being built when the inevitability of the impact was proven with mathematical certitude. Where the hell was his crater, what's-it-called, anyway?

Then Ted realized what was wrong. He was in the Southern Hemisphere, down under, so the Moon was upside-down in the sky. No wonder it looked familiar and all wrong at the same time. He tilted his head to orient himself to the Moon's southern pole.

"What are you doing?"

"Looking for the colonies, but the Moon is upside-down from up north."

"It's all relative."

"It sure is," Ted said, not because he believed that. He did not believe in relativism (as opposed to relativity) at all, but sometimes you agree with someone to acknowledge not what they say, but that you are all too aware of their point of view.

The Hunter rose, not coincidentally Ted's favorite constellation. Orion was upside-down too, but being rather symmetric, it almost looked the same. Different in a disconcerting way. Could Orion hunt as well standing on his head? Would he draw his sword in time and slice Big Bastard to pieces? Or would it be he who slings the asteroid at sorry old Earth?

"I suppose I shall never know what the Moon is like," said Hendrik, "since the positions are all filled."

"Bah!" Ted tamped his pipe with a burning stick. "It's not much different from the old Namib."

"Is that so?"

"But because the gravity is less, the elephants grow much larger." With that, Ted shot a smoke ring at Hendrik, an old gag between them that placed Hendrik at the center of an undulating target.

Hendrik smiled. "You had me going there. Now, I've got one for you."

"Shoot."

"There is an old bushman myth that says the Moon is a goddess. Every month, she shrinks and dies, but then comes back to life. She looked down on the Earth and saw the people dying there. She thought to inform them that like her, they would always be reborn. So she sent a hare to deliver this message. But the hare was grieving his

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mother, who had just passed away, and he deliberately misquoted the Moon. He told the people that once they died, they would come wholly to an end. When the Moon found out what the hare had done, she hit him with a stick, splitting his lip. But she never sent the message again, so to this day, people still believe that death is the end of everything."

"I thought you didn't buy the old beliefs."

"I don't buy them, but these stories are still told to the children, to teach good behavior. Anyway, they can be entertaining, can't they?"

Ted laughed.

They watched the Moon quietly until the grunt of a baboon not far off wrenched Ted into a hunter's alertness. He had already found and drawn his rifle in his mind before the sound registered as harmless.

"You won't hear that on the Moon," Hendrik said.

Ted puffed on his pipe and sighed. "No, sir, I won't."

"Listen, Ted, I've been thinking. You and I are not just tracking that wounded elephant out of mercy, are we?"

"What do you mean?"

Hendrik waved a dismissive hand at the Moon. "Why don't you forget about going back there? Why don't you spend your last days where you belong—here in the bush?"

The last time Hendrik had hunted with Ted, Ted took a trophy. There was also a documentary, replayed occasionally on Hendrik's old pod. That had been part of a program to reduce supernumerary elephants in Damaraland and the Caprivi Strip, globally approved, and organized by the Namibia Professional Hunting Organization. Culling was justified on the basis that the unwary beasts were destroying their own habitat. Of course, discussing the possibility that it was people who were supernumerary was out of the question. Neither drought, mismanagement, nor the culling effect of AIDS could solve that one. Big Bastard, of course, would.

They found the injured cow already dead and so completed their safari. Ted was one of the few who could afford the petrol to run a vehicle, and he departed alone in it, after a heartfelt but restrained good-bye to Hendrik.

Hendrik rode home with his friend Loois, a load of elephant meat in the back. Loois was impressed that Hendrik had been with a hunter of such wealth. Although Hendrik knew the difference, it seemed that to Loois, America was as remote as the Moon itself.

They stopped to trade for some petrol. One whole tusk for a fill-up, a fifty-pounder. Hendrik overheard the man at the petrol station say, "What do they want with petrol these days? They can not drive away from the asteroid!" *Well*, thought Hendrik, *what do they want with ivory?*

They slept on the side of the road, and the next afternoon they rolled up the long hill to Windhoek, nearly home. The city was named Windhoek—"windy corner"—for good reason. The relentlessly dry air scudded over the rocky slope like wind over an airfoil, depositing dust over the parched ghettos, which seemed placed to screen the yellow stuff from the bright city on the hill.

The truck attracted some attention when they stopped at a red light in Katatura. Kids flying noisy kites made from flapping plastic bags came to see what the bloody hulk was on the back of Loois's truck. Women grilling beef patties at a roadside stand glared at the potential competition, and young men came for handouts.

"Hey, Baster, give a little!"

Hendrik ignored the slur. The Basters had long ago made a precarious peace with their mixed origin. They had convinced the world of their pride in the heritage of the name "bastards," but the social complex held secret by the Basters was just that. Complex. Hendrik

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was proud but was reminded daily that things had not changed. His ancestors were half Dutch and half African—Nama, actually. When they tried to opt up socially, they were turned down—too black. They helped the Germans fight indigenous people, only to have the Germans later declare war on them. They were run out of South Africa, only to be courted later as a tactic against Namibian independence. Having learned their lesson, they remained neutral—only to find themselves at odds with that new government. Too white.

The Basters once had their own government under colonial rule, which was more than the other "coloureds" could say—never mind the Africans. This too was gone, but Hendrik was reminded of it every time he looked at his children. His son Oscar was darker than his daughters, so Hendrik had to push the boy that much harder, to help him overcome his disadvantage.

"Give a little, Baster!"

So the insult did hurt, but he gave the man a few dollars anyway. Why shouldn't he? He'd been paid astronomically by Ted Hathaway. And it was better to be a beacon of light than to waste money on beer and cigarettes. These poor fellows were doomed like everyone else, so they might as well have a little happiness.

"Listen, son," he told the young man, as he pressed a few dollars into his hand. "Use it wisely. No drugs or women, do you hear?"

"What do you care, Baster?"

Hendrik felt his head grow hot. "You think that because the world is going to end that your behavior does not matter? This is precisely the time when God is paying attention to you."

"Go on, old man! Your light is green."

"You will be judged."

Loois dropped Hendrik off at his house in Khomasdal. His wife Sarah greeted him on the cinder stones of the yard as the retreating Sun traced its last shadows on the low block wall around their house. They did not embrace outside. Loois helped him unload some of the meat and left.

"How is the black one?"

"Hendrik, I tell you, our son is dying."

Hendrik looked down at her feet. "I know. It doesn't matter as much now, though."

Sarah's brows charged at him. "How can you say that?"

He threw his arm to the heavens. "That damned asteroid!"

"Big Bastard, they call it," she said, watching the orange clouds turn gray. "It's like us Basters, alone in the heavens."

"Woman, what are you talking about?"

"Maybe it's God's way of sending us a message."

Hendrik recalled his words to the beggar at the intersection. *You will be judged.* Now those words drew bile in his throat. "Sarah, do you understand that this is just a little more than a message?"

"Oscar is very ill. That's a fact. You just came back with meat and money from hunting. That's a fact. The girls are bringing their families to see what you brought. Fact. The newspaper says that our traditional Parental Laws have been officially nullified by Rehoboth, and a shooting star might break the world in two. As far as I am concerned, those are just rumors. What will you do, act on the facts, or on rumors?"

"Let's eat," he said, wondering why they should even bother.

Now that Ted was gone, Hendrik returned to his retirement. There was nothing for him to do but go volunteer at the Lutheran church. There were a lot of things to do in the church, a newly painted rectangular building on a hill at the edge of Vaalhoek with a view of the highway to Windhoek. On Sundays there were three different services, each in a different language—Afrikaans for the Basters, Oshiwambo, and Herero. Hendrik spoke all three (as well as Eng-

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lish) and so volunteered as a deacon to the troubled congregations.

Life seemed to go on as usual, with the exceptions of Oscar careening through an ever-changing and bewildering set of symptoms and ever-more dominant news coverage about Big Bastard. Hendrik and Sarah fed their son, kept him warm, aired out his room, and Hendrik took note of a Bible passage about earth, fire, air, and water. These basics to life were no different for his ancestors in the bush or back in the Netherlands than they were to Oscar or to Ted and the other colonists on the Moon.

Life went on as usual—things in Namibia were not progressing at all, and therefore Hendrik felt that he and his people were quite unworthy. He thought of Ted often and talked to the Moon from time to time. "Live well, Ted. You deserve to survive our judgment day."

One Sunday, Reverend Diergaardt quoted scripture in his sermon, a disturbing passage, in the context of Big Bastard.

But he that shall endure unto the end, the same shall be saved.

After the Afrikaans service, and before the Ovambo, Hendrik helped Diergaardt count the offering in the office closet. He used the opportunity to express his concern.

"*Die Bybel* tells us that he who endures to the end will find salvation. How can this be? Does it mean that only those on the Moon when the end comes will be saved?"

"Of course not," said Diergaardt. "You are confusing survival with salvation. Two different things altogether. According to God's mercy will we be truly saved."

"I know one of the Moon men, you know."

"Yes, I know."

"A very brave man. It is those men of men that will survive, while the meek shall inherit the Earth. We inherit it, like a hand-me-down. And then our hand-me-down will unravel, just like that!" Hendrik threw his hands out and twiddled his fingers like cosmic debris.

Diergaardt smiled. "I don't blame you for being dramatic. But don't forget the Exodus, my friend. *The Lord, having saved the people out of the land of Egypt, afterward destroyed them that believed not.*"

A shuffling of hard soles on the painted cement floor outside stopped Diergaardt short. He held up his hand for silence. "There have been thieves about," he whispered in Hendrik's ear. Then he called out a hello.

A deep voice with an American accent replied. "I'm looking for Hendrik Izaaks."

"Come in."

"I was told I might find you here." The American was fairly tall and sturdily built, bearded, with sandy blond hair traced with gray. Hendrik had to study the face for a moment before recognizing Ted Hathaway. "How are you, Hendrik?"

"Ted! I am fine, and yourself?"

"Never better!"

"I didn't recognize you with the beard."

"It's a royal pain shaving on the Moon. Not allowed to get whiskers all over the place."

Hendrik introduced his old friend to Reverend Diergaardt and looked at Ted with great pleasure. "It is impossible to leave Mother Earth behind after all, isn't it?"

Ted smiled, not an affirmation, but Hendrik found it harder to read the face of a man with a full beard and mustache. "Sure it is."

"So you have decided to stay behind. There isn't any big game left, or so they say. No one really knows, because there's not enough petrol to find out. Even so, if you want to try. . . ."

Ted stood so still, it called to mind times when the two of them would crouch motionless, watching game grazing upwind. Then he suddenly loosened

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up and fluffed up a hairy smile. "You know me!" he said, and he clapped Hendrik on the shoulder. "But no, let's talk about it over dinner. Is that place we used to eat still any good?"

Hendrik looked at Diergaardt, who was locking the closet, pretending not to be paying attention.

"It's become a beer hall."

"Shame. That's the last thing we need. Let's go into Windhoek, then, my treat! We'll take your family."

Hendrik and Ted ate alone in a five-star hotel restaurant. Sarah had to stay home to tend to Oscar and insisted that the men go alone. The girls lived in another town and were absorbed with their new families. Ted had an ostrich steak, and frugal Hendrik had chicken. Hendrik did not drink but toasted by meeting Ted's beer with something he hadn't afforded in months—ice water.

Ted drank deeply. "Listen, my old friend, I have something monumental to tell you."

"I will be delighted to hear you confirm my suspicions, that you are staying."

Ted wiped froth from his furry face. "Not a chance, mister. I hate to burst your bubble, but as much as I love Mother Nature, I love myself more. Not many people have a chance like I do, so I have to be willing to take it—take the chance that I can get along without her."

Hendrik put down his water and wished he could see through those whiskers. He knew Ted so well—Ted even said so—and he had hoped that his friend might stay. Now that he thought of it, having Ted around would actually become complicated. Ted had no one and would be happy slogging through the last embers of the Namib when the end came and the sand turned to slag. But Hendrik had a family, and his fantasy of dusty days and starry nights in the bush suddenly fell apart. He splayed his hands out, and then his fingers.

Ted either made a grim face or smiled. "What would you say if I told you I got a seat for you on a starfish?"

"A seat on a starfish?"

"And a room on the Moon, of course."

Hendrik laughed anyway, nervously. "You came all the way here to tell me that?"

"You were right earlier." Ted took another deep draught of his beer. "I can't stay away. But this has to be my last look around, no two ways about it. While I was here, I figured I'd deliver the news in person."

"But what about your ex-wife? I thought you were trying to take her with you."

"Old Dolores would have none of me. Especially when I told her I'd shot a whole herd of elephants just for her!"

Hendrik felt overwhelmed and muddled. "You are serious. How can this be true?"

"First, I am in a position to pull a few strings. Second, I can think of no one I'd rather do a favor for. You did save my life once or twice."

Hendrik gazed at a kudu head mounted on the wall and smiled. Ted had been too eager once and had made a grave mistake. He had ventured into tall grass with his rifle held up, which gave the lion a chance to get between him and his weapon. Hendrik had kept his gun at his hip and took the lion out. "Who would have thought it of the son of a Baster bricklayer?"

"Hmm," said Ted, waving for another beer. "I would."

"So you bought me a room on the Moon. But why would they let me go? I haven't taken any qualification tests."

"Not a problem. I got you entered as prescreened. Besides, things are pretty confused these days. Just show up, tell them you are Hendrik Izaaks, and you'll be on your way!"

"Won't they—"

"It's all arranged." Ted winked. "No one will ask any questions."

Hendrik's mind fogged, and he felt as

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though it was he that had drunk the beer. It took a stable mind a long time to get used to the idea that the Earth would soon be hammered like a mongongo nut. He had no idea how to deal with this development.

"There's more," said Ted, offering Hendrik his second beer. Hendrik shook his head. "I wouldn't have been able to pull those strings, except for one thing."

"What is that?"

"A couple from Keetmanshoop who were slated to go were killed in a riot. The UN diversity pool was thrown out of balance."

"A couple? Do you mean to say that—"

"I'm very, very sorry, my friend. Even I'm not that rich. I could only get one seat. But listen, my final ace was that you represent not only Afrikaaner blood, but also Nama. There is not a single Nama, or even close relative, on the Moon."

Hendrik thought about the old lion attack and about the obscene culling he had helped Ted with. Now this. Tears were running down deep cracks that had rent his smooth skin, and he wiped his forehead with a linen napkin. Despite the killing, Ted was a sort of Noah after all, taking life, and giving it, more than any man should ever be able to. Hendrik never told Ted how ashamed and heartbroken he had been after shooting all those elephants, but he remained loyal, and this was his reward.

It felt like blood money, but was it? There was the inescapable fact that the elephants were going to die anyway. Also, the ivory gave some hope to people, however false. Moreover, some hungry people were fed in their passing; the elephants died a nobler death for that, at least. In the future, looking back, it wouldn't have made any difference.

No, thought Hendrik. No. It makes a difference *now.* It's not the death that condemns a man, but the killing.

Ted saw the tears and laughed encouragingly. "Now you see why my news is just as hard to deal with as you and I gallivanting in the bush together?"

"I would have to leave my family."

Ted nodded and stood up. "No pressure from me," he said. "It's all up to you. If you don't want to go, I'd understand that."

Hendrik stammered. "I don't know . . . what to say."

"You might not even like the Moon, but think of this. You would be carrying your Baster blood forward for your people. Otherwise, it's gone forever."

"Whew!" Hendrik stared into his napkin, eyes unfocused.

"Be right back," said Ted, going off to the men's room.

When one is granted the opportunity, not of a lifetime, but of the Ages, one's choice makes him either a sensible man or a fool. Hendrik could remarry and become the new patriarch of his proud race. Perhaps his descendants would return to Earth someday and mend what was left of it. But how could he leave his family in their greatest time of need? Not just that, but he wanted to be with them more than he wanted his own life. They were his flesh and blood, his soul, and they meant far more to him than his conflicted people.

Ted left the Earth for good, leaving Hendrik with tickets, money, contacts, and other instructions. Everything was arranged. They would arrive at different colonies and would likely never see each other again.

Hendrik sat up evenings, unable to sleep. He had not told his family of Ted's offer. He felt he had to spare his family from the torture that was his alone. He stared at the blank television screen, toying with the remote out of habit. They hadn't had service for a year, though they occasionally resorted to watching pod recordings, like the documentary about culling the elephants up in Caprivi. Lately though, Hendrik could not bear to watch that one.

Now the most frightening spectacles played out on the dark glass. He imag-

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ined desperation, violence, minds growing dim in masses, people turning against one another, fists shaking, and murder. Big Bastard might not kill anyone, because they might kill each other first.

Oscar coughed, and Hendrik heard Sarah tend to him. Oscar was the dark one, the one with HIV, the shame of the household. If he did not love his son, he would have thrown him out for this disgrace—but he did love him. The boy was brilliant, his sisters were brilliant, and he was proud of his Sarah for raising them so well in this hostile place—the land they said God made in anger.

He could not let them face that anger alone when it returned. He could not live in a tin can on the Moon—a place even worse than the Namib—drinking recycled urine, watching Big Bastard butcher the world like so much meat, thinking of his family screaming as some distant continent buckled onto Namibia, dropping cities on them.

I can't save my family or the proud heritage of my people, he thought. *I can't save our beloved, mixed-up blood.*

Hendrik stood up slowly, unlocked the burglar bars on the sliding door, and stepped onto the patio. A stack of cinderblocks stood by the laundry shed. He picked one up and brought it back inside. He relocked the door.

He turned off the imaginary television image using the cinderblock as a remote—he threw it into the screen. The old tube shrieked and imploded like the crack of a rifle. Glass rebounded outward, and the gray block thudded to the rug like a dead elephant.

Sarah shouted in panic.

"It's okay!" Hendrik called as he rushed down the hallway to meet her.

Sarah lit a candle and sat on a painted wooden chair at the head of Oscar's bed.

"What is going on?" she said, the flame's reflection rolling back and forth across her wide eyes.

Like the elephants, like most everyone, Oscar was going to die soon anyway. Looking back, of course, it would all seem the same—that was Ted's philosophy. But no, it *wasn't* the same, not now. Decisions are not made in the future.

Hendrik wrinkled his brow and let it go again with an audible exhale through drawn lips. "Whew!" He swept Ted, the elephants, and even Big Bastard from his thoughts. "Sarah, get the boy ready for a long journey."

Sarah started to get up, as if pulled upward by her raised eyebrows. Confused hope was wringing away her look of fear.

Oscar sat up. "Am I going for some new treatment?"

"No." Then Hendrik thought about it. He knew nothing of the medical facilities in the colonies. Far be it from him to misquote the Moon. "Well, it's possible."

Sarah's eyes had the intensity they had on their wedding day. He smiled at her and took his son's hand.

"Son, listen to me. You *are* going on a journey, and you must use my name. From now until the end, you must call yourself Hendrik Izaaks." ■

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EXTRASOLAR PLANETS AND OCCULT ASTRONOMY

Since 1991 there has been great progress in establishing the presence of planets around some of the stars in our galactic neighborhood. This has been accomplished mainly by observing the "wobble" in the position of a star caused by the gravitational influence of one or more orbiting planets. There have also been some indications of extrasolar planets from observations of the occultation of starlight when the planet passes in front of the star along our line of sight, from gravitational microlensing that changes the intensity of a background star, and from timing of the pulses from neutron stars with planets in orbit. So far, this work has mainly established the presence of planets having a mass of greater than that of Jupiter, since all of these methods are most sensitive to the presence of very large planets.

At this writing (October, 2006) astronomers have indirectly detected 197 extrasolar planets in 97 different star systems. The largest of these (HD 202206 b) has 17.4 times the mass of Jupiter and orbits at 0.83 AU (AU = Earth-orbit radius) around a star very similar to our sun (mass = 1.15 M_{sol}) located 150 light years away in the constellation Capricorn. Some of the newly discovered planets are "hot Jupiters," gas-giant planets orbiting in relatively close orbits. An example is HIP 14810 b, a planet with 3.84 Jupiter-masses and an orbital radius just 0.07 AU from a Sol-like star (mass = 0.99 M_{sol}) located 172 light years away in the constellation Aires. Note that 0.07 AU is a very close orbit. By comparison, Mercury orbits our sun at 0.39 AU. Specialists in planet formation suggest that there should be no Earth-like planets in such star systems, because the hot gas giants in close planetary orbits would sweep up all of the proto-planetary material, preventing formation of Earth-like planets in orbits with the right amount of solar radiation to support the development of life.

However, sub-Jupiter size planets have been found. Among the smallest to date is OGLE-05-390L b, a planet of 5.5 Earth-masses with an orbital radius of 2.6 AU (about the location of the asteroid belt in our solar system). It orbits a relatively dim star (mass = 0.22 M_{sol}) located 21,000 light years away in the constellation Sagittarius. However, its larger planetary mass and orbit and the dimmer sun make this planet distinctly non-earthlike.

This body of work has established a high probability that many stars are orbited by planetary systems, but it would be of even greater interest to identify planets that more closely resemble Earth in mass, orbit, and illumination. There are now proposals for new instruments that would make this possible. In this column I will focus on only one of them, the diffraction-suppressed occulter proposed by Professor Webster Cash of the University of Colorado.

Telescopes like the Hubble Space Telescope (HST) and its planned successor, the James Webb Space Telescope (JWST), have adequate image resolution

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to resolve planets orbiting nearby star systems. The principal problem with directly observing such extrasolar planets is that the light from any star is many orders of magnitude greater than the reflected light from its planets and will completely swamp light from the planet, rendering direct imaging of the planets impossible. This problem, however, may be reduced or eliminated through the use of an *occulter*.

The basic idea of an occulter is straightforward: you simply place a black disk along the line-of-sight to a star system at some distance from a telescope and then observe any planets visible in the star-shadow created by the occulter. In other words, the occulter blocks the light from the star but not from its planets. The distance from occulter to telescope is typically around 10^4 kilometers or more, large enough that the occulter must be located in space and must be carefully navigated into a position where the planets of a candidate star might become visible in the star-shadow over some period of time. It would probably be most optimally used with space-based telescopes like the HST or JWST, but if placed in a movable geosynchronous orbit it might be used with an Earth-based telescope. However, there is a basic wave-optics problem with the occulter scheme.

Light is an electromagnetic wave. When such waves are intercepted by a black disk, the waves are diffracted at the edge, and some of the wave fronts change direction, bending around the disk edge to be deflected into the shadow region. Thus, a truly black shadow is difficult to achieve. In realistic situations, this diffracted starlight is much stronger than the light from planets around the star, and because of diffraction effects a circular disk is not useful as an occulter in searching for extrasolar planets.

Fortunately, there is procedure called *apodization* (Latin for "removing the foot") that can reduce the diffraction from an occulter. This is done by the smoothing or tapering of the sharp edge of the occulter in such a way that the waves from different regions tend to cancel and diffraction is suppressed. In optics laboratory applications this is often done photographically by producing a black disc with an edge that has progressively lighter shades of gray as the distance from the disc center increases. However, such a gray-edge occulter would have many problems in space-based applications. The production, launch, and deployment of a gray-edge photographic image many meters in diameter would produce many logistic problems, and its long term survival in a space environment under bombardment from cosmic rays, ultraviolet radiation, and micrometeorites would be problematical.

Therefore, Professor Cash, working under a grant from NASA's Institute for Advanced Concepts, developed a better idea. He decided to approximate the gray-shaded edge of the occulter disk with carefully shaped blades that either blocked the starlight or passed it completely, therefore producing what might be called "binary apodization." Cash decided to use an average light transmission of the occulter disk that has the value 0 (black) out to some radius R and an average light transmission of $1 - \exp\{-[(r-R)/S]^{2n}\}$ at larger radii. The falloff of the disc edge S is typically about equal to R, and n is typically around 4 to 12. These parameters and the distance F from occulter to telescope are tuned to optimize the occulting performance for the wavelengths of interest in the range 600 to 1800 nm, arriving at the values R=S=12.5 m and $F=5.0 \times 10^7$ m. The result is an occulter shadow that will suppress starlight by a factor of 10^{-12} at 600 nm (orange light) and by 10^{-6} at 1800 nm (infrared light).

The light absorption is implemented by blocking light at the edges of the occulter with blades that resemble 12 petals of a flower. These black "petals" are wide at the base where they join the black disk and taper on a smooth curve

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to points at a distance of about two or three disc radii, so that the "blackness" or absorption as averaged around the occulter is given by the reduction function given above.

The image that the telescope would see with the occulter in place is not completely free of light from the occulted star. The image still contains some diffraction where the blades meet, as well as a halo of zodiacal light. Zodiacal light is starlight scattered from the lens-shaped cloud of dust that surrounds the central star and extends out to well beyond 1 AU. The zodiacal light is reduced by about a factor of 10 by the occulter, but it is not eliminated. However, Cash has shown with simulations that, even with the halo of zodiacal light, at a distance of 23 light years the occulter and the JWST could observe Venus, Earth, Mars, and Jupiter as bright spots in an image taken of the Solar System.

In the environment of space, Cash's occulter scheme appears to be fairly robust. Pinhole penetrations of the black object by micrometeorites should not be much of a problem, since the occulter could be designed to self-seal around small penetrations. Moreover, even if the occulter developed many pinholes, the diffraction effects would spread the penetrating light over an area much larger than the images of interest, reducing its effect. Since the flower-petal edges are either completely opaque or completely transparent, there are no partially transparent gray regions with transparency that might be degraded by irradiation. Cash has also calculated that "bites" removed from the edges of the occulter by space debris can be tolerated as long as they are fairly minor.

What about finding indications of life on such extrasolar planets, once they are found? An occulter system could also be useful in that investigation. The initial atmospheres of most planets are made of hydrogen, ammonia, and methane, with essentially no free nitrogen and oxygen. It is only when life is established that the atmosphere is reprocessed to form an Earth-like atmosphere with free nitrogen and oxygen. The reflected light passing through planetary atmospheres has some wavelengths removed by molecules that selectively absorb those wavelengths. For example, an Earth-like life-bearing planet where photosynthesis is dominant should have absorption lines for O_2 at about 685 nm and 760 nm and for water at 720 nm, 815 nm, and 960 nm. Similarly, the atmosphere of a Jupiter-like planet with no photosynthesis should have methane lines at 610 nm, 725 nm, 885 nm, and 980 nm, and an ammonia line at 790 nm. Therefore, given sufficient exposure time to do spectroscopy on the light from the planet's image, it should be possible to identify life-bearing planets. Moreover, by looking at the time sequence of modulated light from the planetary image it should be possible to determine the rotation rate of the planet and the presence (or absence) of continents.

How long will it take for this phase of planet discovery to begin? That depends on elections, political decisions, and NASA management. Presently the Bush Administration has been pushing its Mars/Moon initiative without providing any significant new funding to support that activity. Consequently, the space sciences end of NASA has been feeling the impact. Projects like planet finding with new technologies may have to wait for a more enlightened administration.

References:

Extrasolar Planets:

NASA/JPL New World Atlas, http://planetquest1.jpl.nasa.gov/atlas/atlas_index.cfm

Occulter:

Webster Cash, "Detection of Earth-like planets around nearby stars using a petal-shaped occulter", Nature *442*, 51-53 (July 6, 2006);

Webster Cash's web site, http://casa.colorado.edu/~wcash ■

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The best legacies
may be things of no
immediately obvious value.

Cool Neighbor

Michael Shara & Jack McDevitt

Illustration by Broeck Steadman

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Greg Cooper had been sitting in the control center of the Weber gravity wave observatory, eating popcorn and calibrating *Icewave*, when he realized he had about a minute to live.

He'd been writing a letter to Kristi Lang, hinting at the discovery he was about to make public, and suddenly it was over. The order-of-magnitude calculation took ten seconds, and told him he was a dead man. Bad karma. He choked off a wave of panic and self-pity. No time for regret. He knew exactly what was coming. The portholes would fluoresce ferociously, down-converting the X- and gamma rays to optical photons for a few spectacular seconds. The last thing he'd ever see.

Warn the people on Clarke: get the tourists back inside.

He opened a channel. "Mayday, Ana, Mayday. Incoming hard radiation. Get everyone back onboard, into the shelter. Do it now!"

Five kilometers away, Ana Vassileva, the observatory manager, gaped at the transmission. The real-time solar X-ray images and radiation monitor live-feed were working perfectly. It was near solar minimum, so Ana wasn't surprised to see nothing at all brewing on Sol. "What are you blathering about, Greg? I haven't seen a sunspot, let alone a serious flare, in weeks. Sol's asleep."

"Ana, the local spatial strain went totally off-scale twenty seconds ago . . . a gravity tsunami just went by. Einstein never dreamed something this big could happen. There's a gamma ray burst right behind it. Get everyone into the shelter!"

"My God," she said, "Marnie's out there in the shuttle."

Ana wasted no time. She hit the alarm and klaxons sounded through the station and its cash-cow hotel. Tourists dropped everything, crowded into the passageways, and headed toward the water and lead-lined chamber nestled in the heart of Clarke. A middle-aged woman with blonde hair askew grabbed Ana in the hallway. "What's going on?" she demanded. "This had better not be a drill, dammit, we had one yesterday."

"It's okay," Ana said. "Just hurry, please." She needed another twenty seconds to reach the Shuttle Control Center.

In the cockpit of the shuttle, Marnie Leeds had backed slowly away from Clarke, allowing her French Canadian guests to ooh and ahh at the view. The hotel-spa was shaped like a clamshell, with ceiling-to-floor windows on the concave side facing Earth. Many tourists spent their entire time on the station savoring the sight, reluctantly leaving the picture windows only to sleep. The Neugebauer Infrared Array hung four hundred meters above the hotel. A thirty-meter telescope anywhere is a remarkable sight, but permanently perched thirty-five thousand kilometers above Africa, it was riveting. The segmented primary mirror glistened with a yellowish hue from its bacteria-thin gold coating.

She looked down at the carbon nanowire space elevator cable, which snaked from the geosynchronous station to the summit of Kilimanjaro. Nearly cloud-free today, the continent was framed between the Atlantic and Indian Oceans. Marnie activated the shuttle's electron beam pointer. She highlighted Cairo, Algiers, Casablanca, Gibraltar, Abidjan, Lagos, Kinshasa, Capetown, Dar es Salaam, Nairobi, and Addis Ababa, circumscribing the cradle of mankind in less than two minutes. Her passengers responded with delight. She opened a channel to Ops. "Shuttle One to Weber. We're on our way. ETA tweny minutes, over." Whichever astrophysicist was on duty in the gravitational wave telescope, he or she knew well in advance when tourists were coming. Marnie always hailed them anyway. Tourists were a minor time-sink for the scientists and techs, but their steady rev-

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enue stream was a godsend, so they were treated like visiting royalty.

Of the whole crowd that rotated in and out of the Weber, she most liked turning the tourists over to Greg. He was one of the few scientists on the project who really enjoyed engaging the public, and he did it with wit and charm. Kids initially reacted cautiously to his sharply chiseled face and intense eyes. His captivating talk of voracious black holes, punctuated with energetic violin playing for illustration, had them pleading for more by the end of a tour. Marnie relished his enthusiastic explanations of collapsing stars and warped spacetime. "The life of every star is a war between gravity and pressure," he inevitably began. "Hydrogen fuses into helium. Then the helium fuses into carbon and oxygen. That supplies the outward pressure to balance the crushing pull of gravity. Gravity is the stellar angel of death." All the while accompanying himself on the fiddle, he usually made a scary face with that one and the kids whooped. "Gravity always wins when a star's nuclear fuel is exhausted."

"Negative, Marnie." Greg's voice, unlike she'd ever heard it before. "Radiation surge coming. Didn't Ana get to you yet? Go back to Clarke. Get everybody under cover."

"Greg, when?"

"Now, goddammit. Do it now."

She switched over to the passenger comm system. "Everybody belt down."

Moments later Ana was on the circuit. Her voice stayed level, but Marnie knew frantic when she heard it.

"Greg." She was having trouble breathing. "Marnie's got six aboard Shuttle One, two adults and four kids. She's coming around. Headed back. Just a kilometer away. Three minutes out, tops. Shuttle Two's still down. We'll turn One around as soon as Marnie's group is back onboard." Her voice quavered. She desperately wanted to order Marnie and Shuttle One to pick up Greg. But even with her fiancée's life at stake she knew the rules. Tourists come first, no exceptions. Ever. "Greg, what can we do?"

A long silence. "Ana, I haven't a clue, sweetheart. I wish I'd said it more often, but you're beautiful and I love you." A pause. Then: "I think we're at the end here."

"There must be something—"

He went quiet again. "Give Kristi a hug. And listen; tell her to read her e-mail. It's important."

Marnie pitched the shuttle 180 degrees in the ten seconds after she'd spoken with Greg. Guidebooks ricocheted off the cabin walls. Frantic yells came from the passenger section. "It's okay," she told them, while she turned sharply toward Clarke's airlock. One of the kids started to whimper. "Hold tight, everyone. Brace yourself!" She gave it a solid thirty seconds of thrust. The sudden acceleration pushed them all into their seats. The shuttle raced back toward the hatch at an illegal fifty knots. The approach was slightly off-center. She tapped the port thruster, and was horrified to see it remain ON after she released the button.

The shuttle bounced hard off the emergency bumpers. Her head snapped sideways into a restraint. Metal tore. Thank God for the pressure suits. Marnie struggled to remain calm as the deploying airbags punched at her. Her youngest charge, Lissette, was screaming. The emergency lights glowed angry red, then failed as the passenger cabin split along its main seam. A hurricane of escaping air tried to suck out her passengers. They were all screaming now.

Stay calm, stay calm, stay calm.

Marnie remembered her training as the airbags deflated.

Don't panic.

Her suit was intact. So was everyone else's. She flipped on her helmet lights, unbuckling the six terrified tourists. Holding Lissette herself, she pushed and

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pulled the family toward safety. The airlock was meant for four. No time for that luxury. She jammed her six wards inside and pushed in after them. Ana's face was on the monitor, giving her a thumbs-up. The inner door closed on her arm and rebounded open. She tried again and held her breath until the hatch closed. The green lamps came on and she slapped the emergency re-pressurize knob. Air flooded the chamber. "Keep your suits on," she told everyone. When the pressure equalized, Ana yanked open the outer hatch. "Around the corner," she said. "Don't stop, keep going, turn right, thirty meters to the shelter." When one of the kids tried to ask a question, she simply shook her head. "Go! Go!" she barked.

Marnie watched her take a moment to look back at the wrecked shuttle. Ana bit her lip. Then she pulled herself into the shielded station core.

Greg saw the seismograph needle twitch twice, then jerk back and forth with growing fury. The oscillations surged, and he watched the arm snap off in mid-swing. Pulling himself to the digital console, he read a peak strain of 10^{-17} on *Icewave*, his cryogenic diamond gravity-wave detector. *No way,* he thought. *Can't be that high. It must be a major system glitch.* But the hundred-kilometer interferometer gave him the same impossible result. "Savor this," he told himself. "You just recorded a gravity wave a hundred million times more powerful than any on record. The neutrino detector guys are about to experience the biggest flash in history. Incredible. Probably fry half their equipment." The cold realization that other, far deadlier radiation was also coming froze the thought and turned his face chalk-white.

It had been over a minute since the seismograph needle had sent its warning. The radiation monitors hadn't budged. *I'm not dead yet,* Greg thought. *It can't be a collapsing neutron star, I'd be toast by now.* "Ana," he radioed, "the strain is so big that it's got to be something nearby."

"What, Greg? What could it possibly be?"

"A supernova. Something massive. Maybe a Wolf-Rayet star. The core might have run out of nuclear fuel and imploded, but the star's outer envelope runs behind the process. The gamma rays coming from the interior would have needed a few more minutes to break through the envelope. Call Kamiokande in Japan, okay?"

"Kamiokande IV is reporting eight hours of right ascension, minus forty-seven degrees of declination," said Ana tensely. "Somewhere in Vela." It had taken her just a minute to reach the duty technician of the world's largest neutrino telescope. Its cubic kilometer of ultra-pure water was two miles underground to prevent false signals from cosmic rays. Most neutrinos raced through the entire Earth without being stopped. But a tiny fraction crashed into protons in Kamiokande's water, generating minuscule flashes of light. Many of the Japanese telescope's trillion photodetectors had saturated during the neutrino onslaught, but the neutrino flash's position in the southern Milky Way was firmly in hand. "Plus minus two degrees is their guess, near Gamma Velorum. Roughly an hour before they can refine the position, but at 810 light years, Gamma's the closest Wolf-Rayet star in the sky. I wish that helped."

Maybe. At the moment, Greg had other priorities. "Okay, Ana, Thanks. It means I have a few minutes more. When Marnie gets back, if you could send the shuttle PDQ, I'd be grateful."

She was silent a long time.

And he knew. "What's wrong?"

"Greg, Shuttle One is scrap." She added a few details as she finished sealing the shelter doors. She was trying not to lose control in front of the bewildered tourists.

"No chance at all?" Greg asked.

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"No," she said. "I'm sorry."

They were on a visual hookup, so she could see him. He nodded and pressed his lips together. Sometimes things like this happen. Nobody's fault. "It's okay, Ana," he said. "Thanks for trying."

He pushed back in his chair, as if it might be possible to draw it around him, to hide in it. *Not exactly my day. I hope it isn't too painful when it comes.* There was nowhere to run. He'd put on his spacesuit for the shuttle trip, but it couldn't protect him from a gamma ray burst. Vela was visible through the port-side hatches. He moved as far starboard as possible, behind some computer racks. Tying up the loose strands of his life took just a few minutes online. He was finishing when the comm link suddenly roared with static and his visor blazed like the midday Sun.

As they suspected, it had been Gamma Velorum. The star had undergone core collapse, producing a supernova brighter than the full moon. Kristi Lang was shattered by the news from Clarke. Greg was the only casualty, thank God, but he had been her mentor and friend, and had provided encouragement and support three years earlier during her Ph.D. research. She now had an international reputation for outside-the-box thinking, and a bit of media renown to boot. She'd concluded, on strong evidence, that a class of brown dwarfs, failed stars, were being used to mark black holes. They were being pressed into service as interstellar lighthouses. It was a wild idea, of course. And, like all wild ideas, it was still not widely accepted. But it would be one day.

Greg would not be there to see it.

Ana had called her within an hour, although the story was all over the media by then. The director had been fighting back hysteria, and Kristi had lent her strength. Hang on, Ana. He had a good life. Our lives are richer because he lived.

Words. What the hell good were they at a time like that? And in the morning, when she was able to get herself together, she found the e-mail from Greg.

It was routine stuff. How much he was enjoying himself on the Weber. How he was at that moment watching a shuttle filled with tourists headed his way. And then there was a P.S.:

There's big news in Sagittarius. A Clyde Tombaugh special. Gotta go. More later.

Clyde Tombaugh was the guy who'd discovered Pluto. What the hell was Greg talking about?

More later.

She gave it a few weeks, and then tried to reach Ana. But she was in transit, on her way to Baltimore. Kristi located her on a glide train and arranged to meet her for dinner.

Ana could not have been called beautiful, but she was an attractive woman, with blue-green eyes, lush chestnut hair, and the kind of presence you associate with leading ladies. Kristi was shocked by how much she'd changed over the few weeks since they'd last seen each other. Ana looked gaunt and her skin was sallow. She was bitterly unhappy and it showed. Kristi gave her a hug. "Are you okay?" she asked.

Ana shrugged. "Not really." Her eyes avoided Kristi, and wandered instead around the interior of the Crab Pot. It was early, and there were only a few customers present. Piano music was being piped in. "I finally got all the reports," Ana began. "Greg got an awful dose. Around 90 Sieverts. Five is fatal." Her voice caught, and tears began running down her cheeks. She managed a smile and wiped her eyes. "It took us over a day to get him out of Weber. He was horribly burned, comatose, and—well, the details don't matter."

"Ana, there's no need to talk about this."

"I need to, Kristi. I really need to."

A waiter appeared. His name was Richard, and could he get anything for

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the ladies?

They ordered Maryland microbrews and crabcakes.

Ana took a deep breath. "He's in cryosusp and his daughter won't let the doctors pull the plug."

"Pity. But I can understand it."

"Did you know we're getting sued, too?"

"No. By whom?"

"The tourists. They've launched a class action claiming negligent design and inadequate radiation protection. A wonder they aren't suing God for setting off Gamma Vel so close to us."

"Any of them get sick?"

"As far as I know, they're fine. They're claiming mental trauma, or that their health was put at risk, or some damn fool thing."

The beers arrived. Kristi was used to touching glasses when she dined with old friends. But Ana simply swept hers up, gazed at it sadly, and took a long swallow.

"Don't they sign a legal release before they go up?"

"Yes. We're not responsible for acts of God. And if a nearby supernova isn't an act of God, I've no idea how you'd define the term. But it'll be at least a year before we can bring back tourists. No tourists, no money. So Neugebauer and Weber and all the other telescopes are mothballed. Everyone is on unpaid leave."

Kristi tried her own beer. "What are you going to do in the meantime, Ana?"

"I don't know. A couple of places have offered me temporary positions. The University of Maryland wants me to come on board permanently."

"I'd consider it."

"You know, Kristi, I don't think I realized how much I was going to miss him."

Salads came. Kristi's was a Caesar. "I got an e-mail from him," she said. "Right at the end. And I can't figure it out."

Ana frowned. "Why not?"

Big news in Sagittarius. A Clyde Tombaugh Special. "You have any idea what he might have meant?"

Ana gazed at the ceiling, and then poked a fork into her salad. Finally she shook her head. "I don't have a clue."

"Nothing you're aware of that he was looking at in Sagittarius?"

"Not that I know of."

"Odd."

"There *is* something, though. I'd forgotten."

"What's that?"

"He told me to make sure you read your e-mail."

Kristi nodded. "The center of the Milky Way," she said, "is in Sagittarius, so that part of the sky is choked with stars. I don't know where to begin, Ana. I don't know what he was talking about."

Their dinners arrived. Ana paid no attention to the food. The door opened and eight or nine people came in, an office party. The hostess showed them into the next room. Lots of laughter and, almost immediately, a round of applause. Ana took a deep breath, and those dark intelligent eyes finally found Kristi. "I'm sorry. Whatever it was, I think Greg's taken it with him."

Kristi went to the memorial service, and said a few words trying to explain what Greg had meant to her, both professionally and as a friend. Then she'd choked up, as several people had before her. She listened to the minister say how Greg was with God now, and in better hands. He was alive and well in a better place than this. She wished she could believe it.

When it was over, she flew back to Pasadena, where she was a junior assistant professor at Caltech. She resumed work, and did her best to forget Clyde Tombaugh.

But it didn't take.

Tombaugh had been born in Illinois to a family of farmers. Despite a limited formal education, he developed a fascination for telescopes at an early age. But

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he didn't think highly of the telescope he'd gotten at Sears. So he'd built his own. He eventually put together his own reflector and took it to Mt. Lowell in Arizona. The observatory director was looking for an amateur astronomer to try to find Percival Lowell's Planet X. Tombaugh hunted through thousands of photographic plates, comparing the positions of millions of celestial objects on successive nights, looking for something that moved. Looking for Pluto. On February 18, 1930, he found it.

She put a picture of Tombaugh on her desk. Clear eyes, good features. Probably in his mid-twenties then. What did you do, Clyde, that connected with Greg?

She got occasional e-mails from Ana, who had taken a position of some sort with the International Space Commission. Then, one evening close to Christmas, she called.

"Hey, kid, how are you doing?" she asked. The winsome smile was back. "You spending another scintillating Saturday night at the office?"

Kristi nodded ruefully. "Yup. It's just the Yottabytes and me. No other way to win that Nobel before I'm forty." Kristi stared hard at the screen. The Spacecraft Control Center logo glowed dimly over her shoulder. "Ana, are you where I think you are? How did you get up there?"

"The yo-yo tourists settled out of court, Kristi. I came back up to Clarke yesterday with a skeleton crew. Just in time. Five months earthside almost killed me. Be happy for me; I'm alive again."

"I am, Ana. You know that."

"I have something here for you. Where did I put it?" She pretended to fumble with her e-pad. "Aha! Yes. A little something for the holidays."

Kristi's e-pad beeped. She looked at what had arrived and gasped. All of Greg's logs. "I owe you another crabcake dinner, Ana."

"No chance I'll collect that meal, Kristi, unless you bring the crustaceans up here yourself on your next observing run. I'm done with Earth. Too crowded, too dirty, too noisy."

Kristi looked at the logs, and at Tombaugh's picture.

Greg had been up there almost continuously for three years. As she paged through the transmission, she saw that she had all his observations and calibrations. Everything.

The proprietary period was normally two years, so part of it was already public. Kristi had long since thumbed through that, hoping to find something that would put her on the track of the Sagittarius sighting. But the recent stuff was something else. It had been released early, probably because of a family stipulation. Kristi scrolled through the lists, trying to get a feeling for what he'd been doing during the past two years. And she discovered he'd been observing every brown dwarf in the Milky Way. *My God, he was trying to prove I'd been right.*

He had also observed every brown dwarf wannabe in her thesis, at higher resolution. He'd collected a billion spectra. *He worked harder than I did.* A lot of his observations were of cataclysmic binary stars, and she stripped those out of the file. She also removed the obvious quasars and Seyfert galaxies that masqueraded as brown dwarfs in her survey. That got her down to twenty million objects. Well, hell, it was a start. Sagittarius occupies just over 2 percent of the sky, but it includes the dense core of the Milky Way. Deleting everything not in Sagittarius decreased the sample size to four million. But now what?

Clyde Tombaugh's photographic plates were her last hope, and she knew it. The plates were taken a few nights apart and Tombaugh had compared them, star by star. Pluto gave itself away by moving nightly, relative to the background stars. Greg's reference to a "Clyde Tombaugh special" didn't make any sense. Only solar system objects

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move enough in a few nights to be detectable. The nearest brown dwarf is twelve light-years away. Its nightly motion would have been far too slight for Tombaugh to have seen. Brown dwarf surveys of the early twenty-first century should have found anything closer. *Greg, what did you mean?*

The riddle gnawed at her. Her other research was beginning to suffer and Sills, the department chair, was visibly worried. "You're up for tenure in a few years, Kristi. Don't get sidetracked by unsolvable problems. You've got to keep publishing."

Months went by with no progress and no publications.

She called Ana. "I think he saw something that moved."

"But you've no idea what."

"No. I'm looking for a needle in a haystack of four million straws."

"It might not be as difficult as it sounds," she said. "If you're right, one must be different from all the others. If you examine Greg's four million spectra for one second each, you'll be done in seven weeks. That's assuming you don't eat, sleep, or bathe, but those are overrated anyway."

The words hit home. *One must be different from all the others.*

The four million Sagittarius objects were an astrophysical smorgasbord. They included twelve classes of cool variable stars whose spectra sometimes mimicked those of brown dwarfs. In her original work with brown dwarfs, she'd needed a year to eliminate these interlopers from her catalog. *Which baby did I throw out with the bathwater?* Every sorting algorithm in *Numerical Recipes* divided the objects into one of the twelve classes. Actually, though, there were thirteen classes. Twenty-two *bona fide* brown dwarfs had slipped into the detritus heap, and Greg had managed to scoop them back out. For the hundredth time, she idly glanced at the first few. They were similar, late T dwarfs, with temperatures around seven hundred Kelvins, hardly worth a second look. Something clicked. *These spectra were too good.* The resolution and signal-to-noise were better than anything she had ever seen. *How did he get such great data?*

She displayed the next six of Greg's spectra. They were all virtual clones. Holding her breath, she overlaid all twenty-two plots on top of each other. *Tiny shifts in radial velocity between them,* she noted. *Otherwise, they're absolutely identical.* "Let's see where they are." She scanned the list of celestial coordinates. All twenty-two objects lay within an area five hundred times smaller than the full moon. *It can't be a cluster of brown dwarfs because they'd have a much larger spread of radial velocities.* She placed the coordinates in a plotting package, and two twists of a corkscrew stared back at her. Bingo! Not twenty-two objects. Just one.

Kristi, you're as dumb as a rock. She sagged into a chair, shutting her eyes tight. The enormity of what Greg had found overwhelmed her. And he'd died in the middle of it. His loss was suddenly clear and crushing. She held the spectra to her chest and began to cry.

Ana was leading the efforts to reactivate the geosynchronous telescopes. There was no way to confirm or extend Greg's discovery without Neugebauer. Kristi called and, on an encrypted line, told her what she'd found.

Ana listened and paled. "Are you sure?" Her voice trembled.

"I need to do some more checking. But yes, I don't think there's much question."

"Thanks, Kristi," she said. "I'm glad you told me. It's helpful to know what he did." She took a deep breath. "Do you need more data? What can I do to help?"

Kristi nodded. "The radial velocities are crucial." She was trying hard not to

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sound excited. "The variations were tiny. Greg must have missed them. I need a set of high dispersion observations every six hours for a month. Can you do it?"

Ana could. "You bet. I'll get started tomorrow."

The Neugebauer data accumulated on her computer for three weeks before Kristi allowed herself to inspect it. The direct images were saturated, just as she had expected. *No wonder,* she thought, *it's so bright.* But the spectra were exquisite.

And they confirmed her suspicions.

She called Ana. "It's what we thought." She bubbled with enthusiasm as she described the results.

"Now what?" asked Ana.

"We need access to the coronagraph." The coronagraph was designed to block the glare of a distant sun, allowing its planets to be seen. "Joel," Kristi said.

Ana nodded.

Joel Dayan had designed and built the coronagraph at Clarke. He was on the staff at Caltech, just down the hall.

Joel blinked in surprise as she walked into his office and shut the door. "Tongues will wag, Kristi," he smiled.

"You wish, big fella." Joel was one of the brightest people Kristi had ever met. He had done breakthrough work on instrument design, was a superb classroom instructor, and had won a Shaw Foundation Prize four years earlier for his imaging of terrestrial planets in nearby star systems. In his spare time, he partnered with an airline pilot as the California state bridge champions. He was also pretty good-looking.

"I need your help, Joel," she said.

He sighed. "What can I do for you, Kristi?"

"I want to make you an offer you can't refuse." She described her discovery, told him yes there was no question, and no she wasn't kidding. She showed him the new data from Ana.

He listened, looked skeptical, nodded. "Greg's work, you say?"

"Yes."

"I never got to meet him." He sat quietly, considering what she'd said. "My loss."

"Can you help?"

"You're asking me if the coronagraph is available."

"Yes."

"Not really. It's never available, Kristi. You know how that is."

She knew. People were lined up for months ahead. "We'd have to get somebody to give up their time."

"I know," she replied. "But you have seven days, beginning this Friday."

"You're offering me a junior partnership in a risky enterprise that might be in the textbooks for centuries." She smiled and nodded. "Let me think about it and I'll get back to you."

He walked into her office an hour later. "Okay," he said. "We can do it."

"This Friday?"

"Yes. But there's a price."

"Sounds like the end of my virtue."

He laughed. "I'll take it if it's available. In any case, I want to go with you."

Three years earlier, Kristi had almost frozen to death in a snowstorm when her car slipped off the Kilimanjaro summit road. This time it was sunny right to the top. The auto-drive let them both enjoy the view. They relaxed and laughed and snacked as the pressurized car climbed more than five kilometers above the surrounding savannah. The *Yuri Artsutanov* Space Elevator was celebrating its thirtieth year of operation. Large banners hailing the international consortium lined the road. This would be her sixth trip up, and his tenth. Security had been beefed up since her last visit. The guards put their suitcases through X-ray, terahertz, and pion imagers. She hated being swabbed for a DNA sample. Joel just shrugged. "Standard operating procedure where I come

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from. Better that than a lunatic bringing a polio-smallpox cocktail onboard in her own body."

The cable seemed to hang from infinity, contrary to the laws of common sense. *Yuri's* base towers were surrounded by enormous structures extruding new nanowire ribbon. The lifting capacity was being doubled to one hundred tons. Competition from the rival elevator, the *Bradley C. Edwards*, anchored due south of Hawaii, remained fierce. Joel and Kristi were the only passengers, so the steward ushered them into the first-class section. *Nice,* she thought. *This is how the other half lives.* They strapped themselves in as the hatches clicked shut. The carbon nanowires stiffened and the elevator lifted away from Kibo, the summit crater. Minutes later they spotted Kigali and Kampala across Lake Victoria. The Indian Ocean came into view and the Earth became round. Venus and Saturn appeared as the sky turned dark blue, then black. Their eyes adapted to the night, and the star clouds in Sagittarius became visible. They talked, drank coffee, and enjoyed each other's company. Toward the end of the nine-hour ride, she fell asleep on his shoulder. He stroked her cheek to wake her just before the clamps on Clarke locked the elevator in place. "Hey, kid," he said, "it's showtime."

Ana was waiting for them. She hugged Kristi and shook hands with Joel. Kristi had warned her to wait for dinner, and Ana laughed when she saw the crabcakes. A complex Stellenbosch Chenin Blanc with a hint of citrus enlivened the evening.

Joel had stenciled HARSH MISTRESS (HM) on his coronagraph, because of the sub-nanometer precisions required to make it work. He'd anchored the core of the device to carbon-silicon nanorods in liquid helium to eliminate flexure. Cooling and testing the alignment was a three-day blur of activity. The instrument was trivial in principle—it used a small metal disk to occult the glare of a star. Its ten-billion-times-fainter planets could then be seen. Detailed images of Jupiters and Neptunes around nearby stars were like shooting fish in a barrel for HARSH MISTRESS. Joel had built HM for his Ph.D., to take the first resolved images of Earth-like exoplanets. A decade later, he had a hundred discoveries to his credit. All were like Mars or Venus, with atmospheres utterly devoid of oxygen. Religious fundamentalists were using this to "prove" that life on Earth was unique and divinely created. He rolled his eyes when Kristi teased him about it. "Nutcases," he said. "I'll need a bodyguard when I find an oxygen-dominated terrestrial world."

A few months earlier, Joel had serendipitously detected two Ceres-sized asteroids orbiting Barnard's star. They were the first exo-asteroids known. The precious observing time they were going to use now had originally been awarded to look for more asteroids around other nearby stars. Greg and Kristi's discovery took precedence, so Joel was going to sacrifice all seven days of his hard-won Neugebauer time to make the necessary observations. *A small price for astronomical immortality,* he thought. *If it works.* And he didn't mind having a very attractive redhead like Kristi Lang feeling indebted to him.

Caltech's press officer reminded Kristi of a bulldog. His cylindrical body and stubby legs supported a square head with sad brown eyes, short golden hair, and a white beard over large jowls. Alan Boxer loved his job and the eclectic scientists whose work he publicized. This morning promised to be a high point in his career. Two hundred media representatives were munching donuts and downing coffee in Feynman Hall, waiting for him to begin the press conference. He nodded, and the Astrophysics chair of Caltech stepped to the podium.

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Albert Sills was beaming. He wore a vest that portrayed the Earth on a navy blue background of stars. It was his way of signaling an Event. "Most scientists count themselves lucky if they make one significant discovery in a lifetime." He gazed out across the audience. "Professors Kristi Lang and Joel Dayan have each done that already. She has found a type of star that nature cannot manufacture. That might be synthetic. He has taken the first pictures and spectra of Earth-sized planets orbiting other stars. All of these planets are barren. Her results suggest that intelligent life exists in the cosmos. His results suggest that extraterrestrial life is absent or very rare. Isn't science *wonderful?!"* When the laughter subsided, he looked toward them, standing off to one side. "This is their day. Doctors Lang and Dayan, please tell us what you have found."

Joel raised the microphone for Kristi and it promptly emitted a deafening squeal. He fiddled with the controls, and a second try brought it quietly within range. "That's why a skilled instrumentalist is so essential for every astronomy team," she began. He laughed with the reporters but looked nervous, so she gave him a broad smile and faced the media. The New York *Times* and *Science* correspondents had been tipped off, and were sitting on the edges of their seats. *They get it,* she thought. She savored the moment, gloriously happy, for herself and for Greg. She almost felt his presence in the room. "Welcome," she said. "I'm pleased that so many of you are here. We want to gratefully acknowledge our co-author, Ms. Ana Vassileva, who couldn't be here today. She is spacewalking at geosynchronous altitude right now. Ana manages the health and safety of our instruments, and has gathered some of the data for our work. We're going to take fifteen minutes to summarize our discoveries, and then we'll be happy to answer questions." The corkscrew appeared on the holoscreen beside her.

"Greg Cooper sifted through a billion rejected brown dwarf candidates from my doctoral thesis. Only members of our own solar system move enough, relative to the background stars, to be easily detectable in a few days. That's why I rejected all rapidly moving star-like objects. They must be asteroids or Kuiper Belt objects. Greg re-observed them, and all the other rejects that varied. One, and only one, of my rejects displays the spectrum of a brown dwarf. And it turns out, it *is* a true brown dwarf. Greg re-observed it every month for almost two years. The twenty-two points of the corkscrew that you see on the screen plot the apparent path of this object across the sky. A single turn of the corkscrew has 1/30 the apparent diameter of the full moon. That's huge." She took a deep breath. "The only way that can be true, ladies and gentlemen, is if the brown dwarf is a binary companion"—she paused—"of the Sun."

The audience sat stunned. Somebody murmured in back. Shocked expressions appeared on the reporters' faces.

"The brown dwarf's orbital motion around the Sun carries it continuously in one direction," she continued. "The position from which *we* view it varies cyclically over one year as the Earth moves around its orbit. Combining those two motions produces the helical path in the sky. The apparent size of the corkscrew helix places our newfound neighbor about one hundred times farther from the Sun than Neptune: five hundred billion kilometers away. That's a pretty long walk. But it's *still* a hundred times closer than the nearest star."

Hands were going up all over the conference hall. The reporter from *Science* didn't wait to be recognized. "If it's so close, why hasn't anyone discovered it before?"

"There are five reasons," Kristi said. "Our companion is almost a million times less luminous than the Sun. It's three thousand times further away. We can never see it in the same spot twice,

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because it takes 150,000 years to complete one orbit. For the past eight thousand years, it's been moving through Sagittarius, the most crowded part of the sky. And finally, it's eight times cooler than Sol, so it only emits infrared light. That's why nobody's ever noticed our cool neighbor until recently. Until Greg Cooper did." She took a sip of water, and touched her e-pad.

"We've measured the brown dwarf's radial velocity. It's wobbling back and forth with perfect periodicity every seven days." A sinusoidal curve with data points and error bars replaced the corkscrew on the holoscreen. "This means that a significant mass must be orbiting our neighbor, tugging it back and forth."

A hand went up. "Are we talking about a *planet*, Professor Lang?"

"One second, please, and I'll explain. Dr. Dayan's state of the art instrumentation permits us to measure the object's speed as it orbits the brown dwarf. That helps us pin down the masses of our two discoveries. The brown dwarf is forty times the mass of Jupiter. If it were eighty Jupiters, it would fuse hydrogen, and be visible to the naked eye as a blood-red star.

"The orbiting mass is three times that of the Earth. But it's divided." She looked at the reporter, and at her audience. "To answer your question: No, we do not have a an orbiting planet." She paused. "We have *two*.

"Ladies and gentlemen, we apparently have a miniature solar system, just eighteen light-days away." The hands had gone down, and the excitement had turned to stunned silence. "We thought you would like to see them. Dr. Dayan?"

Joel touched his e-pad and two fuzzy crescents appeared on the screen. "Dr. Lang and I spotted *these,* in the first image we took. At first I was certain that the double image was an internal reflection in the coronagraph. We rotated the optics by 90 degrees, but the crescents didn't budge. They are real, nearly identical twins. We are seeing both night and day on each world's surface, hence the crescent shapes." Another touch and two much sharper crescents filled the screen. "Several hours of focusing the instrument brought us to where we could take a crisp image every minute. Concatenating them gives us the first movie of twin terrestrial worlds, which we'll now see."

The planets came alive, circling their common center of gravity. They orbited the brown dwarf in perfect lock step. On one world, cloud masses swirled over continents, islands and oceans. The second planet was totally enshrouded in clouds. Flashes that could only be lightning were visible on its night-side. Many of those present broke into spontaneous applause. Joel smiled and nodded. "During the last few hours of our observing run, Dr. Lang measured each world's spectrum, and I now ask her to describe what she found."

Kristi returned to the microphone. "Humanity has the technology today to send a robotic spacecraft to our neighboring brown dwarf star and its twins. If we use the Clarke cable as a whip, we could be there in twenty years. And we *are* going to go. Let me show you why." The holoscreen displayed another pair of spectra. "The ocean world has water in its atmosphere, of course. There's oxygen, ozone, and methane, too." She stopped, took a deep breath, and thought again of Greg. *I wish you were here.*

"The spectrum also shows a distinctive feature *here* that can only be produced by chlorophyll. The other planet, the cloudy one, shows nothing but carbon dioxide and nitrogen. *The ocean world is alive.*"

The academics in the audience sat spellbound. Many of the reporters were already filing stories with their e-pads.

"Life has taken hold on a planet just eighteen light-days from Earth. It has failed on the twin planet right next to it. If we choose to do so, we can learn why

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life established itself on one and not on the other. And then, perhaps, we will understand how life got started on Earth."

Joel squeezed her hand beneath the podium. "Great, Kristi," he whispered. Lise Meitner must have experienced the same wave of joy when she proved that an atomic nucleus could be broken into smaller parts. Kristi had never felt more alive. "Ladies and gentlemen, thanks for your attention."

A forest of hands mushroomed in front of her. ■

(EDITOR'S NOTE: Kristi Lang and Greg Cooper appeared earlier in "Lighthouse," April 2006)

IN TIMES TO COME

Shane Tourtellotte has been showing us a series of visions of the future in which "overlays" can be used to reform human beings in a way far beyond the means of old-style "reformers," by effectively rewiring their brains with traits deemed more desirable. Initially, of course, the method was used on a small scale and with great caution, to turn the most "incorrigible" criminals into people the rest of us could live with. But one thing led to another, and next month's novella "Trial By Fire" is what the author describes as the crisis point of the whole series. Given some success with such a new and powerful tool, what happens when a culture-wide trauma suddenly provides an irresistible temptation to use it on a far larger scale?

We'll also have stories by, among others, Michael A. Burstein and Robert Greenberger, John G. Hemry, and Jerry Oltion, plus Part 2 of Karl Schroeder's serial *Queen of Candesce*. Richard A. Lovett provides the fact article, "The Ice That Wasn't," about archeological evidence of a time when some of our ancestors' early efforts at global warming may have unwittingly averted a genuine catastrophe.

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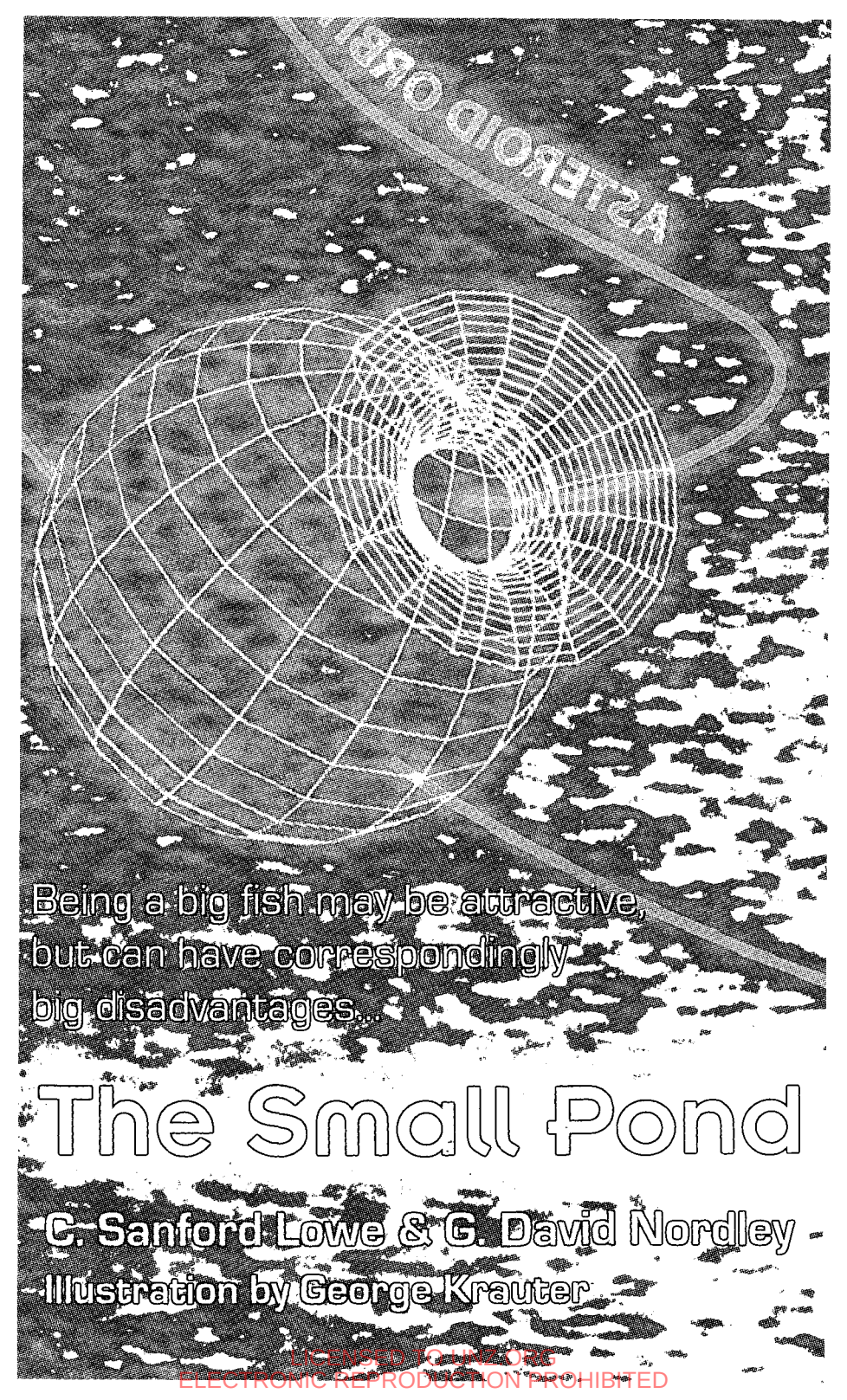

Being a big fish may be attractive, but can have correspondingly big disadvantages...

The Small Pond

C. Sanford Lowe & G. David Nordley

Illustration by George Krauter

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Chapter 1

In the Solar System's Kuiper Belt,
9 May 2250

"Return? Return!? But we just got here! Nobody's even been down to the surface yet!"

The surface floated in front of Liz Avonford, forbidding, mysterious. She put a hand on the *Marsden's* observation window as if to touch the unknown planetoid below them. It drew her to it with a force far greater than its negligible gravity.

Salim shook his head firmly. "Orders from Dr. DeRoot. We have to go back. Besides, we didn't tell them we were going to land. I think Vitus DeRoot would rather someone else be the first on the surface. This is the biggest thing found in the Solar System in the last century—it's over 300 kilometers across! It's historically important. The institute would want to be involved in the landfall decision. We've got a big fish here, and we aren't expected to be catching big fish. We should get permission."

"Nuts!" she said. At 3007 AU's from Sol, it was her call. "I'm going down for a couple of hours at least. We're too far out to be calling back to headquarters. It would take a month to get permission."

"Thirty-four days, sixteen hours," the *Marsden* added, helpfully. "25 August 2250."

"Look, they didn't say so in so many words," Salim said, "but . . ."

"Nuts to the politics! I found it. And I'm going to be the first one down."

Silence. She was the expedition commander and the legal authority in place, unless Salim or someone relieved her. And they would not do so over this; no one had expressly ordered her not to make landfall.

Liz grabbed the doorjamb and projected herself across the deck to the nearest excursion vehicle. She checked herself smartly with a hand slap on the cockpit rim, pivoting her legs onto the seat. A quick visual showed the standard equipment was all present, including a helmet and coveralls in the wire mesh locker behind the pilot's station.

"Activate and close up," she ordered the module.

Two hours later, she was on the planetoid's surface, leaving the first human footprints on its regolith of coal-black cosmic dust.

She crouched slowly to keep her feet on the ground and set an analyzer on the surface.

"How old?" she queried.

The display inside her helmet projected 7.219 gigayears.

"Salim, this thing is older than the Solar System! Over seven billion years! It didn't come from here!"

Salim's groan echoed through her helmet, so loud it made her wince. She sighed. Bad enough to make an uncoordinated landfall on a big ice ball, but this was an uncoordinated landfall on a major discovery. She would go down in history instead of someone much more senior. She straightened her shoulders. That, she thought, was just tough.

Two months later, Liz was back on Earth at Saint Petersburg, in Vitus DeRoot's office at the top of a very tall ISA tower overlooking the Nevsky Prospekt. DeRoot, she thought, was all the more terrifying because of the way his friendly avuncular manner could mask his anger.

"Shall we go through the particulars?"

Liz willed her fisted hands to straighten and shook her head. She had a good idea of what would be on the list—every piece of negative information about her performance since she arrived in the Earth's Solar System.

He was going to do what he was going to do.

"The executive committee feels that we should take advantage of your family connections and the public attention your exploits have received in our outreach program."

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Visions of intro classes and faculty teas rushed through her head. "With respect, Dr. DeRoot, I've not had any university experience. I did my degree onship, on the way in from 61 Cygni."

He smiled. "Not to worry. We can accommodate you in both respects. Ginny Lu has a long list of elementary schools over the entire planet that need speakers. It would be a real treat for the children to meet someone who was born around another star, and is so famous. You'll be assigned to her. Anything else?"

"When does this all start? I have a milk run to the Black Hole Project in the asteroid belt."

DeRoot shrugged. "I wouldn't worry too much about the BHP; that's just too premature and grandiose—Director Zhau Tse Wen's political problems will shut them down before too long."

Liz felt a cold chill down her back. Was that what was behind this?

"Hilda Kremer, your sister, is on that project, is she not? I'm sorry." He frowned and looked down.

Liz bit her tongue.

"You colonials come back here with so much enthusiasm, but this is a very old solar system and a very old planet with agendas that go way back." He shook his head. "One needs to tread carefully. Are we done?"

DeRoot had simply made a personnel move based on "needs within the institute." It had already been decided. What was done, was done.

She left DeRoot's office and went to her apartment on the thirty-second floor. There she opened a bottle of Mayagues Port, went out on her balcony, and looked out over the Ploshchad Ostrovskovo, awash in the late summer sun.

She thought about her mother, the near legendary starship Captain Katherine Avonford, as she looked at the huge Russian monument to Catherine the Great. Its larger-than-life scale also reminded her of her planet-sculpting father, Wotan Kremer. She had vowed not to be swallowed by her heritage but also, perversely, felt obliged to live up to it in some way, to be larger than life herself. She shuddered; time enough to get things back on track tomorrow. With that she set aside a couple of detox pills and proceeded to get smashed.

The next morning, Liz went back to her small office in the exploration division. The door wouldn't open. She groaned, then wiped her hand and the handle to aid the ancient fingerprint recognition system's ability to recognize her paw.

It still wouldn't open.

A soft beep sounded that only the person standing in front of the door could hear. Liz touched the net for admin.

I am sorry, but you are not authorized entry to this office, came the reply.

Of course I am! Liz sent. *I'm Elizabeth Avonford and this is my office. For a while, anyway . . .* Her stomach tightened as she realized what had happened. Chaos! It had only been ten lousy hours!

A young man, a tall blond, came down the hall toward her, followed by a cartload of boxes. As he reached her, he smiled winningly and stuck out his hand.

"David Levi." He pronounced it dah-FEED leh-VEE. "A visitor already! As you see, I haven't moved in yet."

"It's my office," Liz said, knowing she was wrong.

Levi stared at her.

Liz sighed, deflated. "At least it was. I think my stuff is still in there."

"Oh, dear." Levi looked concerned. "Let's see."

He put this hand on the pad and the door opened. The office was bare.

"Damn!" Liz said. She'd only had it for three years, and most of that time she'd been in space. Still, there were memories—her first real job.

She looked at the wall where the pictures of her family had hung. The empty shelves that had held a few precious real

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books. Even her snow kitten doll was gone.

Levi looked mortified. "I'm sorry, I . . . They just assigned it."

Liz shook her head and wiped away a tear. "It's not your fault. I'm sure the service robots have stashed my things somewhere." She composed herself. "Well, what do you do?"

"Bionanotechnology. I got my doctorate at Jerusalem United fifteen years ago and finally got a position." He stepped aside and the cart moved into the office with his things. "Only so much to do and a hundred and twenty-three billion people to do it."

Liz smiled and shuddered inwardly. She had a sudden insight into what resentment there might be towards her or any other colonials taking up positions.

"And you are?" Levi asked.

Liz hesitated, then sighed. He'd find out soon enough. "Elizabeth Avonford."

His eyes went wide. "The person who just discovered the new planet three thousand AU's out? Captain Kate Avonford's daughter? And I'm taking your office? I'm very sorry!"

She smiled falsely. "Bureaucratic error. Uh, ten days before spring or after autumn equinox, the sun sets right behind the old fort. Enjoy it. By the way, it's a kuiperoid or planetoid or whatever—not a planet." She turned and walked to the elevator.

As she entered her apartment, she realized she had to talk to someone. She touched the net for her older sister, Hilda.

Hilda, I just got my ass fired. She took a breath. *Help!*

A few minutes later, her sister was on her wall screen. Hilda had inherited wide-set blue eyes from their father, Wotan Kremer, and a long nose so much like her own that, in certain positions and lighting, it was almost like looking in a mirror. But Hilda's hair was an almost platinum gold, while her own locks were more reddish brown, attesting to Catherine Avonford's Celtic lineage. And Hilda had a strong chin. Liz often thought about having her own enhanced.

"Good morning, Liz. What's happened?"

Liz unloaded. "I don't know what to do next," she concluded.

Hilda appeared thoughtful. "Look, Dr. Sarah Levine has changed her mind about going to Lacaille 9352 to work on the fabrication and the launch of its impactor for the BHP. You're used to command and an expert in space resources. Interested?"

Liz caught her breath in the thrill of the offer. Eleven light years away, at a start-up interstellar colony, she would likely have a major role. Then she hesitated. "Hilda, I don't work for people very well. I'm, well, kind of bullheaded."

Her older sister smiled knowingly, but instead replied, "You've led four expeditions since you got into Earth's Solar System, all successful."

"Well, yes, but when I do an expedition, it's my show."

Hilda looked pointedly into the camera. "That's what I'm going to recommend."

Liz opened her mouth and couldn't close it. *In charge of the whole show? No boss, no politics? Eleven light years from Earth with nothing to do but make it happen?* She looked at her sister, excited, almost breathless. "You're kidding . . . You're not kidding. You think I'd have a shot?"

Hilda laughed. "That bullheadedness, along with your ability to improvise, is probably just what we need. There's a man out there named Gunheim, former PM of Queensland, given to grandiose schemes. He'll probably be in local politics out there, and if he starts interfering, it will take a strong will to stand up to him. We've got a planning meeting in a few minutes, so I've got to go. Should I ask Tse Wen?"

Liz caught her breath. The responsibility would be huge; a monstrous pro-

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jectile of precisely the right mass would have to leave Lacaille 9352 at just the right time and reach just the right velocity to meet the three other projectiles with nanosecond precision at the experiment vertex. A small pond, yes. But she would be the big fish in it. That excited her. And making the Black Hole Project happen would be an exquisite revenge on that arrogant, disingenuous bastard, Dr. DeRoot. But . . .

"Hilda, we haven't had much time together."

"I know. But I may be heading out myself. Dad's headed back to New Antarctica; he and I have some issues to put behind us. The project needs a local lead. There are other political problems, though. Sis, we have all eternity ahead of us. Let's get together at New Antarctica when it's done. Maybe mom will come."

Liz grinned. "Now *that* would be interesting. Okay, I'm in. If Tse Wen wants me, I'm ready."

She signed off and touched the net. *Any starships headed for Lacaille 9352 in the next year?*

The C.E. Singer, *Peter DeRoot commanding.* It would leave Venus Equilateral in eight months.

DeRoot? Any relation to the Director?

Brothers.

Probably irrelevant, Liz thought, but just bad luck if not. The *Singer* was her only choice. She stored the information and turned to her apartment window. Gold and pink clouds floated in the sky beyond the Ploshchad Ostrovskovo. She looked to the northwest, toward the lands of the Vikings and of Nansen and Amundsen. There was so much she hadn't taken time to see.

Chapter 2

Between Sol and Lacaille 9352,
23 September 2264, Sidereal Reference

In her third day after emerging from hibernation, Liz Avonford lay on a towel on the grass by a tiny pond under the warm artificial sun of the starship recreation dome, eyes closed. Linked to the computational power of the starship via bioradio and the local net, she was hard at work, simulating orbital motions in the Lacaille 9352 system.

At a time compression of 10,000, the planets of the system traced their orbits. Two small ones, Sunbeam and Canning, lay close in, surrounded by the orbits of a pair of larger worlds, Venus-like Carlisle and Mars-like Martin. Further out was a thin belt of asteroids, then a pair of gas giants, Munro and Spencer, which might have been twins to Uranus and Neptune. Beyond those rolled an icy Plutonian world, Rayl, at the inner edge of a wide ring of kuiperoids.

A brilliant flash and afterglow in the inner system caught her eye. That must be it, she thought—the impact that would occur in the Lacaille 9352 system a dozen years from now. She replayed the last hours of the collision in real time and high magnification. A largish asteroid approached Martin, the Mars-sized world, slowly, gracefully taking a whole second to cover its own diameter to start with. One thousand one . . . But the asteroid sped up as it approached the planet until over the last two or so planet radii, it was sucked into the Mars-like body in a flash. Liz stared intently as a great enveloping black cloud boiled out of the wound and spread around the whirling planet. She sighed at the great stroke of cosmic luck that would let her be present at such an extraordinary catastrophe.

"Elizabeth Avonford?"

But the luck wasn't all good; it would happen just at the end of their BHP impactor's acceleration. Debris splashed from the collision could easily interfere with the vast solar arrays and beam drivers needed to send their impactor on its way. She asked the computer to light the array's position in vivid green, trailing and fading over several million virtual kilometers. The debris made a virtual

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cloud that spread from Martin inward and outward, and the edge of the cloud touched the ring of power stations that would power the Black Hole Project. Should they divert the asteroid for one revolution? Or change the time-mass-velocity profile to get the beam out before the impact?

"Elizabeth Avonford?"

The sound of her name penetrated, and dimly aware that it was the second time she'd been called, she groaned and opened her eyes, disoriented. Reality was calling her back from the virtual universe and it took a moment to adjust, like waking up from a dream.

Her eyes got into focus. The man who had spoken to her had a familiar accent, but she couldn't quite place him. "Yes?" she replied.

"David Levi."

She touched the ship's database and made the connection.

"Oh yes. You're the young man . . ."

". . . from Israel, who took your office." He chuckled. "I quickly found out that was no place for anyone with an independent soul!"

They shared a rueful laugh.

"Your first time on a starship?" Liz asked.

David nodded. "I stayed awake; watched the Sun shrink to a point of light and redden. I didn't realize how red it was going to get. The safety lights in the observation bubble gave me the clue—when our gamma hit two, it seemed almost as red as they were."

At a gamma of two, the starship was moving at 86 percent of lightspeed—stretching the Sun's yellow light to red. "That's clever; I hadn't thought of doing that."

"We should get to see it again as we slow down approaching Campbell."

Liz's eyes widened. "Campbell?"

David smiled. "AKA Lacaille 9352."

"We?" Liz asked. She liked him instantly.

"Judi Lalande, Su Ahng-Lo, and the Captain—those of us who have been awake the whole trip. Lalande is an astrophysicist doing research en route. I understudy Ahng-Lo with biosystems; I shall have my credential and experience by the time the voyage is over."

"Looking to ship out again, then?"

"I must see the universe and it is good to have as many qualifications as one can acquire. As soon as I solve the mystery of that kuiperoid you found."

Liz raised an eyebrow. "What mystery? Other than it's clearly something the solar system picked up from somewhere else."

David grinned, delighted to pique her curiosity.

Liz touched the net again; within the errors of measurement, her planetoid was the same age as the Lacaille 9352 system—make that the Campbell system—7.392 billion years, plus about 3.6 million or minus 2.2 million.

"That could be a coincidence," she started.

David looked at her, a glint in his eye. "I think it is nearly a twin of the rock that's going to crash into Martin, maybe even the other half."

"The other half?"

"A rapidly rotating binary rock comes close to a giant planet, like Munro, and gets pulled apart. The slower half goes into a chaotic orbit around Campbell. The faster half gets ejected from the system entirely."

"This happened recently? Campbell is moving very rapidly."

David nodded. "But in a halo orbit about the galactic center that turns out to be commensurable with that of Sol. They come close every 560 million years. Three times around for us, two for it."

"That's still an incredible coincidence."

He laughed. "Oh, I do not think it is so much. There are five hundred billion plus stars or near stars floating around that big black hole in Sagittarius. What are the odds that none of them come close to Sol periodically?"

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Liz chuckled. "Well, if you put it that way . . ."

He nodded and his eyes blazed. "Now I go a little off the path that is beaten. About 560 million years ago, life on Earth got a good, uh, kick in the trousers."

"The Cambrian explosion?" She began to roll her eyes. "That's way too much of a coincidence."

David shrugged. "That is why I've said nothing, officially, yet. But I think maybe I will find some biology around this red star we go to. And I wonder if it is biology we have already seen."

The importance of what he said sank into Liz. An independent origin on Earth, or an import from elsewhere . . . "Campbell is almost three billion years older than the Solar System . . ."

David's eyes glowed. "Ah, you understand!"

Liz thought about her finding the kuiperoid, their chance meeting in the hall of the administration tower, and now heading together for Lacaille 9352, sharing the same passion to do something significant. Perhaps there was something to fate.

"Are you busy for dinner?" she asked.

"What about lunch?" he countered, delighted by her attention. "It is almost lunchtime now."

She laughed. He was as eager as she was. But she had an engagement. "The captain offered to show me his collection of ancient navigation equipment. He's going to establish a small museum at the Minot Space Colony around Campbell. I'll be in his quarters for lunch."

"Well, dinner then?"

Liz allowed herself a slight smile. She had to be a decade older than him, even subtracting the years she'd spent in cold sleep. Was he looking forward to more than just dinner? The prospect was not entirely unpleasant. "Okay," she smiled. "1900 in Sphere One."

Liz touched the net for a map. The *Singer*'s habitable parts consisted of six spheres spaced hexagonally, like beads on a stiff hoop, around the magnetic field generation cable. Between spheres, sections of a torus enclosed the wire and a passageway. The ship spun about the hoop axis for stability under thrust along that axis and for centrifugal gravity. The heavier lower half of each sphere rotated on the hoop to keep its floors level under any combination of acceleration and spin. The diagram showed the floors parallel to the spin axis, as they were now with no axial thrust. She was now in Sphere Three, with most of the other passengers. Sphere One, two spheres antispinward, was crew country.

"Captain's table, then?"

Liz nodded. Let him think he has competition.

Liz looked forward to seeing the old hardware and was a little early to Captain DeRoot's quarters. On the way, she passed a woman who looked upset and gave Liz the strangest look imaginable, but said nothing and hurried down the access tube.

Judi Lalande, the AI identified.

Each sphere had four decks and a mess. By tradition, Room 131 on deck three of Sphere One was the captain's quarters in all ships of this design. In her voyage to Earth as a teenager, she'd never come close to Room 131; Captain Yuri Ivanov had been a serious, forbidding figure who smiled at girls maybe twice in a voyage. Remembering that sense of forbidden territory came back to her now. Liz had captained her own exploration craft in the Solar System, but here in this moment on the *Singer,* she was an excited child again.

The captain's door slid silently open as she approached. He was at his desk, seated with his back to the door. Overhead was a set of shelves holding various pieces of metal equipment with dials, buttons, brass tubes, and lenses that all looked strange to her. The room itself was no bigger than her own.

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"Come in, come in," he said, almost as if irritated. Then he turned and smiled. "Peter DeRoot, and you are the redoubtable Elizabeth Avonford?"

She nodded.

Instead of rising to shake her hand, he pulled a brass tube from his desk and offered it to her. "It's a telescope made five hundred years ago or so. A whaling ship captain out of Lisboa, Portugal, used it in the early eighteen hundreds. Go ahead, pull it out."

She grabbed the end of the tube and pulled; it slid easily out to a length of about half a meter.

"Does it work?"

Captain DeRoot got up and motioned toward the side of his cabin. An ordinary man, he wore his hair relatively long so it flopped over his forehead in a careless, boyish way. In contrast, his bearing and reserve spoke of self-confidence and authority.

A door opened revealing a room with a polished wood-grain table surrounded by plush chairs. She walked in and gazed around; the walls, except for one, were hung with real framed pictures of sailing vessels and spaceships. She smelled real wood. The wall without pictures had a great box mounted on it with shiny brass fittings—hinges and a hook. The wood was varnished so deep and lustrous that it seemed still wet.

Captain DeRoot walked over to the box, lifted the hook, and swung its doors open, revealing a black shiny surface. "Lights," he said softly.

The lights went out, and as her eyes adapted, Liz could see stars slowly spinning around, except for one bright one. A direct view window! "How . . ."

"The inner and outer windows line up during the coast phase," Captain DeRoot said. "Go ahead, try the telescope."

She put the tube to her eye. After a slight adjustment of the length of the tube, she brought the golden point of light into focus. "Oh! A bright violet star," she said. "It seems impossibly small and intense. Is that Lacaille 9352?"

"That is its communications laser, blue shifted by our velocity. By the way, Roger Gunheim says Lacaille 9352 is called Campbell now, after an author who wrote a novel about using solar energy to power space flight about three hundred years ago. The planets were named after characters in it."

She felt his hand find her waist in a gentle, if presumptuous way. Her heart pounded. Was this really happening? She moved his hand away.

"I thought that wasn't official," she said, going back to the telescope.

"We're a long way from the Interplanetary Astronomical Union."

She felt his hand again.

Captain DeRoot laughed. "And, I am in charge here."

His hand moved up from her waist toward more intimate territory. It had been a very long time since a man had touched her that way, and she felt both fear and excitement. But her mind told her this was too soon, way too soon. Liz pulled one hand free of the telescope and gently removed the captain's hand.

She felt momentarily rattled. He clearly meant it in a friendly manner, she tried to convince herself. Then she flashed back to the look on Judi's face.

"You're going to Campbell to take charge of the impactor project," DeRoot said, "to see that it gets made and flung toward the implosion site."

"Yes."

"There are people on site already with much more experience who can do that."

"Zhau Tse Wen sent me."

Captain DeRoot quietly chuckled. "At the risk of paraphrasing myself, we're a long way from Dr. Zhau. The man in charge at Campbell is Roger Gunheim. He's a nice enough man as long as you do what he says." DeRoot's smile was genuine, but his eyes were penetrating.

Liz carefully kept her voice level. "He's got a whole colony to worry about. I just have the BHP operation."

"Roger is a good friend of mine. We've

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made the Sol-Centauri voyage twice together, without hibernation. There is much time to think between the stars, about how things are . . . and how they should be. Now I could put in a good word for you. . . ."

Or not, she realized. Chaos! There it was, bald and simple. She could give the bastard what he wanted, or maybe risk everything she'd come for—everything she'd promised Hilda she'd do.

Liz went through her internal arguments pro and con. She craved power and she didn't want to risk losing it. She wanted to be in charge and wanted it in the worst way. It meant never getting kicked out of your own office at the drop of a hat, never being humiliated like that again. She could pay the price. She could take a shower afterward.

She let the captain lead her back into his room.

The dinner table was almost full when she and Captain DeRoot arrived; she felt as if every eye was upon her. What did her face look like? Did they know?

"How was your visit to 131?" David seemed cheery and oblivious.

But a dark knowingness in Judi's eyes screamed to Liz. Liz sent her a message on the ship's net. *It's not what you think. He wanted something from me, I wanted something from him. Nothing emotional. Besides, I've had worse.*

"I got to see the brass telescope. We looked at Campbell and the comm laser," she said to David.

A nervous smile flickered across Judi's face. *What does he have on you?*

What does he have on you? Liz answered.

Judi frowned. *My kid. A custody judgment. He could take the kid to his father and leave me here.*

"Captain DeRoot has an interesting collection. Did he show you his working reproduction of that ancient Greek computer? He made it himself." David, of course, had replied to what she'd said aloud.

Liz touched the net for data on the device and recognized it; it had been on the top shelf in DeRoot's bedroom. She'd stared at it during his heaving climax.

"I saw it."

Come on, what's he got on you? Judi came back.

My job. She gave Judi the details.

"Uh, ladies, is something going on?" David asked.

It must have been transparent that they were exchanging net messages. Liz gave a quick glance toward Captain DeRoot, but he was explaining something to an entranced female passenger, one of the last to come out of hibernation.

Liz gently shook her head. *Later.* Aloud she bantered, "You wouldn't believe it. Well! Any luck with your panspermia studies?"

"Oh sure. Did you know that there are at least forty stars that made visits to the solar neighborhood? Five of them came through at roughly the same time as Lacaille 9352. . . ."

After dinner, David found himself walking back along the curve of the access tube with Elizabeth Avonford.

She seemed subdued, and he tried to think of something to say to cheer her up, but when he opened his mouth he shut it again. What was one supposed to call her? Dr. Avonford, Elizabeth, or Liz? He deferred to his more normal upbringing and compromised on Avonford. Okay, maybe Elizabeth Avonford, he thought.

She looked increasingly upset, so he risked seeming foolish. "What's wrong?"

She stopped in the passageway and looked into his eyes, her face hard and weary. "I shouldn't say anything."

David watched her sigh, knowing she needed to unload. He waited. Finally, she began to talk.

"The captain has certain connections at Campbell. Those connections can help or hurt me. He also has certain . . . needs."

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David risked touching her shoulder. "There was a threat implied?"

She nodded, holding back a quiet anger.

"I understand this well. It is not the act that bothers you so much, but the feeling that you have no choice in the act, am I right?"

She nodded.

Why, David wondered, should the artificial intelligence that really oversaw this starship permit such a transparent abuse of its human master's power? But he could answer his own question; ultimately people had insisted on a person being in control.

He spoke. "You have an interesting problem. For instance, if we were to present evidence to the second in command and demand that he take over, how would we know that the second in command is not either complicit or otherwise under the primary's control?"

Avonford shook her head. "We don't. What is the check on such people?"

"I think the threat of exposure would hold much weight with him," David told her. "He could find himself with nowhere in settled space to go. But to fight this would not be without risk."

"If it was just me," she said, "I'd raise hell. But the whole human universe is counting on me to get this job done!"

This seemed a little much to David, who took a longer view of things, but her sincerity and enthusiasm were evident. He smiled and raised an eyebrow. "Is it that important to study relativity? Why?"

"Look, if the Anderson, Lu, and Yoseph paper is right, we can use one asteroid-sized black hole to make more."

David shrugged. "And then what?"

Her eyes gleamed. "Look up Wheeler, Forward, Thornsen, and Zhau. With several black holes, we can make some of the gravitational machines that the relativity theorists predicted. For instance, imagine a gravitational catapult that would send us up near the speed of light without our feeling any acceleration at all! Imagine . . ."

David held up a hand. He had his own doubts about what people might do with the fruits of the project. But it was obviously so important to Elizabeth that she was willing to be used for it. He was moved to concern.

"Look, we live forever these days. If there is a setback, it can be overcome in time. Besides, who knows where the captain's demands will stop? His behavior must be changed, or many more women will experience what you have. I think you must threaten to expose him. Then you will be in the driver's seat."

She raised her eyebrows. "It can't be just my word against his, and we can't count on the ship's AI."

David smiled. "I do biological nanotech. I have in my room all I need for bench-level fabrication. What we need to do is record an hour or so of conversation with something too small and diffuse to be detected by all the usual precautions, which I'm sure that he will take. So I make a distributed network of nanocells. I could hide it under your skin, or in your hair."

Liz looked at him, worry in her face, but with anger and excitement, too. She nodded, not feeling powerless any longer.

David met Liz again the following evening. They listened to the recording of Avonford's noon encounter. DeRoot had walked right into it.

"What would Gunheim do for me if I did this?" Avonford had asked in a totally playful and innocent voice.

"Let you run your project, most likely," DeRoot had said.

"And if not?" She'd asked laughingly, but David noticed a hint of strain.

"Well, the converse, I would suppose. Will you take off your clothes, now?"

"Enough," David said. He had what he needed. She could have walked out right then, he told himself, and if she had not . . . Well, he didn't want to know.

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All locked in, Liz told herself. They had the recording, and the evidence was already on its way to both Earth and Campbell, encrypted, but in a way that would be released if the AIs involved did not get positive instructions from her to not release it. David had been very clever to come up with that insurance policy.

In the last twenty-four hours, she and David had developed a closeness she'd never felt before. No man had gone to bat for her like this, and she allowed the pure warm feeling to wash through her for a moment.

Still, she felt nervous as hell. David might not have anticipated everything. Judi had declined to be a part of it. She still had too much at stake. DeRoot could get back at her without anyone being the wiser, she'd said. David had reluctantly agreed. Besides, they had enough without her, hopefully.

They walked into the Sphere One Commons. DeRoot, waiting for her, frowned a bit. Not expecting David, Liz thought.

The captain recovered quickly. "Ms. Avonford, good to see you. Mr. Levi?"

"Captain," David said, "I suggest that we sit down. We must discuss something with you. I suggest you tell the AI to not record what we have to say. I think you understand what this is about."

DeRoot frowned and pursed his lips, then he looked at her. The threat was silent, understood.

She looked back, just as cold. She hoped her refusal to back off was every bit as clear.

At length, DeRoot nodded.

Without any further word, David produced a comm card and played back the segment with the incriminating language. "We have taken the necessary and obvious precautions, and have supporting evidence of other kinds concerning other events, not involving anyone on this ship," he said afterward.

The last was a complete lie, Liz knew, but one that might give Judi some protection.

"You will understand the implications for both you and Mr. Gunheim," David said.

DeRoot stared coldly at her, ignoring David. "You goddamn whore." His voice rumbled in anger.

Liz stared, unable to help the start of a tear, but willing herself not to give an inch in this contest of wills.

No one spoke. Each looked at the other. DeRoot's face tinged pink. David watched in amazement. Liz valiantly worked on a poker face, wondering if this was the first time the captain's persona and behavior had been questioned to such a degree. He was a smart man; surely he would take this no further. Liz watched quietly. Only when she thought the steam had gone out of DeRoot did she glance at David.

"It's your show now," the younger man said.

She nodded. "Captain DeRoot, I want your assurance, and Mr. Gunheim's, that there will be no interference with my work in the Lacaille 9352 system in support of the Black Hole Project."

He snorted. "That's beyond my power."

"You had best hope not," Liz countered.

"It may be in the best interest of the ship to have you two hibernating for the remainder of the journey."

He might, Liz realized, be able to order the ship's AI to do just that. Then, while they were totally out of touch, any sort of revenge might be orchestrated.

"Then," David said calmly, "we would be unable to keep the encrypted data from being released where we have sent it."

"A moment." DeRoot turned away from them and stared at a wall screen that showed stars gliding by with the ship's rotation. They waited.

Then he turned back and smiled. "Very well. I apologize. I'll speak to Roger and Cyan, I'm sure there will be

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no problem." He sighed. "Eternity is a long time, and if our paths cross again, perhaps I won't make such a mess of it."

"For the rest of this trip, don't even think about it," she replied.

DeRoot rolled his eyes up and nodded. "Well, enjoy the rest of the trip, Ms. Avonford, Mr. Levi. If you need anything from your Captain, don't hesitate to ask."

They were back on record, Liz surmised. She nodded and led David away. As soon as they were halfway around the tube and out of sight and sound of anything, she pulled him close and squeezed him with all her not inconsiderable strength.

Chapter 3

At Minot, Lacaille 9352
(Campbell) System, 5 October 2272

David couldn't help but gasp as their shuttle exited the access tunnel into Minot, the main Campbell system residential habitat. He, Liz, and Judi had flown in from the south pole, where the landing docks were, into what looked like a huge Chinese lantern, its insides filled with fields, forests, and streams. Beside them was a snow-covered alpine terrain in the shadow of a huge dark disk that floated ahead of them.

"That's the back end of the secondary reflector," their guide shouted over the hum of the shuttle's fans.

David nodded and smiled; they'd retracted the shuttle canopy and were sitting in the crisp open air, feeling and smelling very much like a bright, late winter day in St. Petersburg. The scale still overwhelmed him.

Liz Avonford grinned at him as the crisp breeze of their flight streamed her hair behind her. His heart beat faster, anticipating. She had long since succeeded in convincing him that she wasn't just being grateful for helping her, but was deeply into the erotic arts. She initiated everything—instructed, taught, and occasionally used him to achieve her own erotic nirvana. He worried a bit about being so totally dominated, about just being along for the ride. But what a ride!

They nosed down and began scudding over the sculpted, snow-covered crags of polar Minot.

"Ten minutes to Lenore," their guide announced.

They crossed the sun line. Rock and gravel gave way to terraces of meadow, and soon the first trees shot by beneath them. The vastness of the habitat spread out around him, and he thought about Moses on the mountain, viewing the Promised Land. That reminded him of the New Israel space colony, orbiting Proxima, and Ben Shalom, the messianic anti-Moses who had led so many of the orthodox to the stars. The debates about that had filled the coffee houses of Ashqelon in David's childhood. It had been the first of what were now over a thousand exclusive ethnic or religious settlements among the nearby stars, and not everyone was happy about it. Children raised in such places faced the same kinds of survival challenges as youngsters in cults faced on Earth.

Liz touched him and pointed.

He looked in that direction and saw a small rustic cabin by a stream between waterfalls—the first sign of human habitation he'd seen.

"Getting warmer," Liz shouted. Their weight increased as they moved farther from Minot's rotational axis, and the shuttle's fans got louder as they revved up to carry the load.

David smelled the pine forest—now yielding to the more deciduous trees. "It looks a lot less settled than the space colonies around Sol," he shouted over the fan noise.

Liz smiled and pointed to her head.

David opened his address.

Only about five thousand people so far, Liz sent. *L-5 Grissom has fifty-seven million, and its area is a little smaller.*

The land lay mostly flat below them now, a calico patchwork of forests and fields, some tended by cultivating robots.

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A herd of kangaroos! Liz noted.

Roger Gunheim is Australian, David sent. *A town is coming up.* A broad, winding river circled the inside of the habitat at its widest part. A large clearing with wide, low, modernistic architecture lay ahead of them on a thumb of land.

That's Lenore, Judi sent. *Named for Lenore Lebois. She was the first system exec, and she died mysteriously. I guess you have to die to get something named for you.*

Judi, what do you think happened? Liz asked.

Gunheim had his way with her all the way out. They'd just finished the colony when his buddy, DeRoot, arrived with another thousand passengers. That was forty years ago. The two of them got a council formed that made Gunheim the executive. Lenore objected and she was found dead in the river near the town, not three weeks after it started flowing.

Suicide? David asked.

Ruled an accident. But her personnel files disappeared.

This isn't all on the net.

That's right, Judi said. Then she leaned forward in her seat so he could hear her voice over the buzz of the shuttle's fans. "DeRoot told me. Trying to scare me, I think. It worked."

David shivered.

The shuttle passed over a town that would not have appeared out of place in Australia four centuries ago, and settled onto a well-manicured grass field. A group of horseback riders came out to meet them with spare mounts. DeRoot, who'd come in earlier, and Gunheim were among them along with a Eurasian woman.

"G'day and welcome to Lenore," Gunheim shouted, all ebullience and smiles. "Mount up! It's Suits-off Day; thirty-nine years since we moved in here. There's roo on the barbie for you."

The smell of roast meat, well seasoned and basted, wafted in a gentle breeze from the barbecue pits along the river. Liz looked around at the fortieth celebration of Suits-off Day. What a difference a year made! She knew most of the people; everyone connected with something outside Minot itself along with their friends and relatives, maybe a couple of hundred people all together.

Liz sat at a wooden table with her deputy, Cyan Mutori, Judi Lalande, and her son Oscar—and David. The last looked incredibly primitive as he chewed on an emu rib.

Roger Gunheim strode up a small hill near the tables in full outback regalia—safari shirt, walking shorts, and a wide-brim hat with one brim buttoned to its crown. He lifted a ridiculously large Bavarian-style mug of local brew and shouted, "To the success of all our projects!" Then he flipped the cap back and chugged.

Liz laughed, lifted her much smaller glass of Lenore stout, and took a sip. The reflection of Campbell, as much a heat lamp as a light, warmed her skin.

As BHP director, her project for the last year had been to supervise some twenty people scattered around various asteroids and to make key architecture decisions for their busy but not-all-that-creative robot laborers. The fabrication of the impactor was ahead of schedule, and the combined power/beam modules were on a schedule that had at least some margin. They'd become like a family—all dedicated to accomplishing the greatest human project since terraforming Mars.

With one exception.

"Gotta lid on Terry Peal?" Judi asked.

Liz laughed. That particular exception was more interested in setting robot armies one against the other than in mining. He'd also been spouting anti-project propaganda to anyone who'd listen. "He's been eased aside, and others have taken up the slack. We're on schedule."

Here comes da boss, Judi warned.

"G'day, mind if I join you?"

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Liz looked up at Gunheim. "You shot this?" gesturing at her roast kangaroo.

"With a cross bow. A fair shot and it was near the end of its natural life span," Gunheim told her.

Oscar looked confused and moved closer to his mother.

David tossed his head. "When deer become old and feeble, they hurt a lot. That is where hunters come in and end suffering. It is either hunters or wolves, I think."

"Oh," Oscar said, with a furtive glance at Gunheim.

"You have wolves here?" Liz asked.

Judi looked at Liz. *With Gunheim's kind around, you don't need wolves.*

Liz frowned. As far as she could see, Gunheim was all glad-handing and bluster; a little shallow, but harmless.

"Dingoes, it would be. But we haven't introduced large predators yet, mate, and may not for a while. The grass contains a weak contraceptive, so the herds grow more slowly," Gunheim said. "Well, I didn't come over here to talk about hunting. Liz, we're a kind of family around here."

"Great to be part of it," Liz said, feeling all warm and relaxed with the stout. A splash from the shore caught her attention; shorts and halters littered the riverbank beach and shouts of laughter and splashes beckoned her. She'd worn a red towel kilt and matching halter and was beginning to feel overdressed.

Gunheim nodded and beamed, but his eyes were sharp. "Well, in families one shares, and, well, the council and I think it's time to share a little of your workload, let some others get some more of the action."

Liz couldn't believe what she'd just heard. The warm fuzzy feeling evaporated almost instantly, replaced with a cold knot in her stomach. She smiled weakly and tried to hide her feelings. "I'm not exactly overworked."

Gunheim shrugged. "Well, maybe it's just that some other very capable people have been under worked. At any rate, there's been some friction, and whenever anything like that happens, those of us who are in charge have to make some response, tweak the organization, do something of that nature, just to let people know we're on the job."

Liz suddenly felt naked and cold.

The table fell silent, everyone looking at Gunheim.

"Now don't take this too personally. I don't think anyone can really fault you for doing something about Terry Peal and his bloody robot wars, but you're pretty young yet, and sometimes it takes a little more subtlety to keep everyone happy."

"Chaos, how subtle did I have to be! I just let Ivan Marenkov take over the stuff Peal wasn't doing anyway."

Gunheim shook his head. "And you left him off the production achievement list."

"But he wasn't producing."

"You could have lowered the threshold instead of bloody humiliating him." Gunheim's last few words had a bit of snap in them. "But then," he went back to his avuncular style, "these are things some experience brings. You're doing fair on the impactor fabrication now so we thought we might let you concentrate on that and let Mutori take over the people management chores."

"You don't understand, Mr. Gunheim," Liz said, trying to keep a mixture of anger and fear out of her voice. "My sister, Dr. Zhau Tse Wen, and the whole project expect me to see that the efforts in this system are completed on schedule. When you come down to it, the BHP is why this colony exists at all. I *can't* just walk away from that!"

"And you aren't. The decision has been taken out of your hands, so you aren't breaking any promises. No worries."

Liz shot a look at Cyan Mutori, who smiled sympathetically, but said nothing. Judi left the table with her son so quietly that Liz didn't realize she was gone. David sat openmouthed. He was

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running the biosurvey on the asteroid that would soon impact Martin and was, she knew, very vulnerable to what had just occurred to her.

Payback time, Judi sent. *He just needed an excuse.*

A wave of rain clouds spiraling down from the south pole darkened the sky over Liz's dome, transparent when not in use as a display screen. Under it was her one-room office, kitchen, bedroom, and entertainment center; a small, high-tech outhouse hid behind some shrubbery. In actuality, the shrubbery formed the walls of her abode; in the tropical climate of the low latitudes of Minot, an occasional splash of warm rain was an easily acceptable trade for the feeling of openness and freedom this style of living gave her.

But not today. Noon and still in bed, Liz lay under the sheets, head in the pillow, reliving every moment of her life from when she decided to go down to that rogue kuiperoid in the Solar System, to losing her office, to staring at DeRoot's ancient Greek computer while he used her body. At least that had been partly voluntary; a choice, a trade. This time she had been truly raped without a stitch of clothing touched—utterly humiliated in front of her friends in a format so public and genteel that she couldn't even have thought of screaming.

Well, she could scream now! Out in the woods over a kilometer from the nearest other home, she spun in her bed, flung her arms out, and screamed a nameless, primal scream until her throat hurt.

"Liz?"

She caught her breath and screamed again.

"Liz, are you okay?"

It was David. Chaos, she was no mood to be social.

"Are you okay?"

"Does it sound like it?" she snapped, and regretted it. Suddenly, she didn't want to be alone. "Oh, come on in."

He came through the short entrance maze and walked under the dome rim just as large gray raindrops began to splash all over it, drumming in a way that made it sound like more of a storm than it was. She got up to meet him and collapsed on him, sobbing.

He held her until she collected herself.

Finally, when her face had dried and she'd started thinking again, he disengaged slightly and put a hand on her chin. "Liz, it has been three days. Have you eaten anything?"

Three days? She could still taste the emu in her mouth.

"We are all concerned," David said, "but we are being very circumspect. Mutori wants you to know she had no idea this would happen. Judi is terrified."

"I haven't had a message from her since . . ."

David nodded. "We think Gunheim is monitoring bioradio. One wrong move and Oscar is in cold sleep on the next starship to his father. Look, I'm uncomfortable." He waved his hands around him and smiled wryly. "What do you do about bugs in here?"

"All the insects here are genetically engineered to avoid human pheromones so I don't need . . ." Liz thought about the other kind of bugs, then shrugged her shoulders. "Oh. You want to take a walk in the rain?"

David smiled and nodded. The rain was warm and the forest was full of wonderful, wet fragrances. About a hundred meters along the path to the river, he turned to her.

"Okay," she said, to herself as much as to David. "What are my options?"

"Your options? For what?"

"To get back in charge of the project. To put Gunheim in his place. To get my life back."

"Brainstorm?"

"Yeah. Let's have some ideas. Everything on the table. I could kill the bastard. Don't look at me that way; we'll de-

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select later. Maybe we could just kidnap him, put him on ice until after the impactor flies."

David shrugged but didn't look very encouraging.

"Okay. Am I good in bed? Good enough so that someone as experienced as Gunheim would do stuff for me?"

"Liz, you are not serious . . ."

"It's on the table."

"I am not experienced enough to know. You are only my third lover and it is hard for me to tell."

"Well, it's on the table, anyway."

"As a last measure, I hope."

Liz laughed. "If that. Now, could I invoke authority?"

"Earth is a long way away."

"But life is a lot longer these days. Twenty-five years, back and forth, can go just like that. Does he really want to have the most powerful people in the Galaxy pissed off at him forever?"

David shook his head. "If he were rational, I would think not. Okay, on the table." He grinned at her.

"That's the spirit." How was it that she was now cheering him up?

"We could try blackmail again. It worked once."

They looked at each other.

"For a while," they said almost simultaneously, and laughed.

"Back to the authority option," David said. "Gunheim is not an absolute authority here. He must answer to a council."

Liz shook her head. "Which has been very compliant, it seems."

"We could at least argue the case. Show his relationship to DeRoot and their history. We put all the facts before them. They are people."

"They are Gunheim's people."

David shrugged. "That does not mean that their brains have ceased to work. Anyway, they are the ultimate authority here."

Liz shook her head. They were not the ultimate authority. "David, they are elected. He doesn't have to control ten people, he has to control ten thousand! If I can get an election called, the AI will recognize the electorate as the ultimate human authority. He won't be able to fix it."

David frowned. "Perhaps. But are you suggesting a frontal public assault? That burns any hope of making any of the other options work. It would be a gamble."

"But a clean, open gamble. We can expose him and DeRoot."

"Liz, he is a good politician. Somehow, I think, you will end up looking like a dirty whore. And many people who agree with you will not be able to say so publicly. Judi and myself, for instance."

"You won't back me?"

"I can't. I would lose my project. I am taking great risks even talking to you about it."

"But you are talking."

He nodded. "There are people here he can't threaten so easily, and people who remember Lenore. . . ."

Three weeks later, in Liz's now certified bug-free home environment, David glanced at the latest projections, displayed in various graphs on her dome. The good news was that in plastering the truth about DeRoot and Gunheim's escapades all over the colony, Liz had gotten two council members to support her and enough signatures on an election petition to start a campaign. Out of a hundred and fifty supporters, she found enough candidates for a reform slate that, if elected, would control the Campbell system governing council. That had gotten the AI to override DeRoot on monitoring political activity. The bad news was that Liz had, at best, maybe twenty percent support. Forty-six percent of the electorate either thought she was a troublemaker or didn't believe the charges at all, and thirty-four percent didn't know what to think, or weren't saying.

"Liz?" Cyan Mutori's voice rang out

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from outside the hedge. That she was using voice instead of net was interesting, David mused.

Liz nodded to him. He got up and slipped quietly into the nearby woods. Cyan Mutori was probably the last person who should know he was actively helping Liz in her campaign. Gunheim had made it very clear to him that while he recognized, with a wink, David's personal relationship to Liz, any public attacks from David would, in Gunheim's words, "be a mite disruptive to your research program, mate."

"Hello, Cyan. Come on in," Liz said when he was safely out of sight. Her voice carried clearly in the still evening. "How's the project going?"

David felt for Liz. Gunheim's next move, of course, had been to remove Liz from her remaining role as impactor fabrication specialist.

"I would like David to hear what I have to say," Cyan said. "I understand the precautions you take. I am not offended."

David was startled. Had she seen him? Or did she just reason he would be here? There was much more to Cyan Mutori than one realized.

"Come on back, David," Liz said.

He reappeared from the woods.

Cyan nodded to him, with no hint of a smile or a frown. She wore a green sarong with white flowers and a white orchid in her long, jet-black hair—South Pacific, squared. She'd even browned her skin somehow; lamps, probably, David thought. Campbell didn't put out enough ultraviolet light to make a tan.

"Physically, the project is a little behind schedule, but okay," Cyan began.

"Behind?" he asked.

"Deliberate delays, I think. If I counter them completely, I may be removed because these delays represent the will of someone powerful." Cyan shut her eyes for a moment, then opened them. "But if I let them become too great, the project will be in jeopardy, and I will be the scapegoat. It is a very delicate situation."

David shook his head. "You are risking a lot. Look, as I understand it, the worst thing that can happen is that if we don't launch, the other impactors get diverted, and thirty years later we all try again. It's not worth a whole lot of suffering. Pun not intended."

Liz shook her head. "David, I don't know that human politics will allow another chance. The project takes too much discipline and it's too visible. Every one of the launch sites has to be able to push the project through at the same time, without any more coordination than a quarter-century round trip communications delay. We have to do it here if we possibly can."

"Liz, you're fixated," David countered.

Cyan shook her head. "Liz, David. Gunheim is not trying to stop the project. He has, I think, something worse in mind, and that is why I am here."

Liz turned to her and stared. "What could be worse?"

"He came to me yesterday with a question. 'Now,' he asks, 'if one impactor hits a little less hard than the other three impactors, there would be a little momentum bias in the final product, wouldn't there be?'" Mutori shook her head. "He does not understand several things."

Liz said nothing, but stared at Mutori, shock all over her face.

"What?" David said, uncertainly. "He has done simulations, of course."

Liz looked at him, whitefaced. "You can't just 'do' simulations. You have to know when approximations are good enough and when you need another couple of days of number crunching. And," she paused, "there is still too much we don't know about how matter behaves at such energies and densities. It's hard enough to do a symmetrical zero-biased simulation. Chaos only can tell what would happen if something was even as much as a nanosecond off."

Mutori shook her head. "He is talking momentum, Liz. Hitting at the right time but with just a little less momentum. A

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slight amount of momentum bias would send the hole back this way, where he could gain control over it. He would then have, I think, very great power."

David gave her a blank look, consulted the net, frowned grimly, and said, "Oh."

"Power, literally and figuratively," Liz said. "David, this isn't just about me and my job anymore. The reason Hilda sent me out here was because I'd be absolutely loyal to her and ensure that everything be done exactly right. I don't mean to insult you, Cyan. You're a good person. But the project needed that certainty. Humanity needed that certainty."

Cyan looked down. "I took entirely too local a view of things. I compromised. I am sorry."

David tried to digest what he heard. "Gunheim. In charge of a black hole!"

Liz snorted. "That's hardly the worst case. One other thing that might happen is that the hole comes jetting this way. If it doesn't have enough mass, it might be ready to explode in a final burst of Hawking radiation, converting millions of tons of mass into hard radiation in a fraction of a second. Perhaps right in our faces."

"It sounds like a good argument for not trying this at all. What if someone else has the same idea? Maybe we *should* shut it down."

"David!" Liz sounded horrified.

He gave her a lopsided grin. "Just thinking out loud. Okay, I'll give up my project and support your reform slate publicly. Do we have any more options?"

"Black hole formation is not all that Gunheim does not understand. I think he thinks I will want to share his power with him—that I will be his compliant partner in exploiting the black hole and . . . in other ways."

David looked at her expressionless face. Why am I surprised, he thought.

"I came to make an apology," Cyan said. "I shall make my apology in this way. I am local, a first colonist. Some think that by watching much, and saying little, I have leadership qualities. So like David, I will sacrifice my position, and I shall run for the council on your reform slate as its leader. That may change the political dynamics in some small way. If I am so lucky as to be chosen by our people and the council as System Executive, I shall give the project back to you, Liz. Will you accept such an offering?"

"Cyan!"

David watched the two women embrace—his eyes riveted to the beauty of it. Much later David realized what he'd been witness to. That demure, self-effacing, shy speech by the achingly beautiful, vulnerable Cyan Mutori might prove to be one of the most devastatingly effective power grabs in the history of any democracy.

Chapter 4

At Minot, 15 March 2274

Liz stared at the poll numbers floating in the air. Cyan's slate was still marginally ahead, but . . .

"The undecided have the real lead," David remarked.

"People don't want to contribute to a bandwagon effect, whoever they support," Judi said, while throwing a Frisbee to her son, Oscar.

"A bandwagon would be fine with me," Liz said.

Liz, this is Cyan.

Liz pointed to her head, letting the others know she was getting a transmission. *Go ahead.*

We have a problem out on Canning. Terry Peal went off the deep end.

Liz registered the name with a start. *The robot wars guy? What's he done?*

He kidnapped a dozen people in a construction shack. He has decided the Black Hole Project is a bad idea and should be shut down. There may be some political pressure to do that if people's lives are at risk.

Crap, Liz replied. *Are the people really in danger?*

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Our psychometric filter has Peal at eight out of ten on the Kaczynski-McVeigh scale. He could think those who do not agree with him, or simply work on the project, are morally complicit or can be sacrificed. We must do something immediately. Unfortunately, I think I will need to stay here because of the politics. Would it be possible for you to go to Canning and deal with this as my emissary?

Liz touched the net quickly—the KM scale had been around since the twenty-first century and measured a propensity for rationalized violence. Peal sounded like a problem that needed fixing, but . . .

Cyan, I'm not, officially, part of the mining operation anymore.

You are now. This is an emergency. You know Peal.

Gunheim will unappoint me fast, and maybe you, too!

I do not think he would do anything so arbitrary during the campaign. He would, however, make me pay for it if I am not successful. You are the most logical choice because you have the greatest commitment. Also, having you involved may make Roger angry, and angry men sometimes act unwisely, to the profit of their opponents.

Now or never, Liz thought. *I'm on my way. Liz out.*

"What was that?" David asked.

Liz pursed her lips. How much should she say now? "Terry Peal again. David, have you ever heard of a couple of psychiatrists named Kaczynski and McVeigh? There's a scale relating to antisocial conflict . . ."

David's eyes went wide. "Liz, Kaczynski and McVeigh were not psychiatrists."

Liz felt another chill.

"Twentieth century American political killers," Judi said. "Liz, what gives?"

She told them. "David, can you arrange a shuttle to Canning for me?"

He nodded. "What do you have in mind?"

"Making a hero out of myself."

"How?"

"Don't know yet, but I'll have to do it there. I'll need to get on my way before Gunheim figures it out." She gave him a brief embrace and started trotting for the Lenore Landing Field.

It took her forty precious minutes to get a fan car, then another twenty for it to glide its way to the north pole port facility. When her fan car arrived at the port facility, the human attendant was grinning ear to ear.

Her heart jumped. The man worked for Gunheim. Was she already too late?

"I get a nice break today, it seems. You've got the last shuttle."

"Really," Liz said, wondering how close they'd come to disaster.

"Dr. Lalande's people just reserved all the others for various astronomical missions. Something about getting a wide baseline for a predicted supernova in a Fornax dwarf galaxy."

All right, Judi! Liz quickly wiped off her smile, nodded smartly, and climbed into the spacecraft.

Liz catnapped and watched the Canning news feed on her thirty-hour journey.

Gunheim's handpicked team was at least twelve hours behind her—Cyan had managed to hold things back for almost two hours, and it had taken another nine hours to get an interplanetary shuttle.

Liz followed the news for a while. The politics had gone as predicted with Gunheim criticizing Cyan for mismanagement and Cyan patiently explaining how things had developed—making sure the media 'uncovered' how Peal had used Gunheim's influence to amass a lot of robotic parts with little oversight. Gunheim had started talking about project fanaticism on the part of some people and how human life had to come first and how everything had to be on the table as long as people's lives were at stake. Cyan had quietly asked just how much people were willing to be governed by terrorists.

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It was late at night when Canning Base spaceport passenger-access-tube snaked its way to Liz's shuttle. The only one to meet her at the inner door was Todd "Mac" MacGregor, a nervous, sandy-haired young medic whose wife was one of the hostages.

"Why," he asked, "is this impactor schedule so damn important?"

Liz bit her lip and answered carefully. "The impactor your people are making," Liz explained, "has to match perfectly the other impactors in density and dimension as well as velocity to produce the necessary symmetry at the impact point. It's slow work, even for robots, and once our margin is used up, no way to make up the time. Peal has cut off the flow of iron to its assemblers, so we've already lost most of the margin. Further delay could ruin the efforts of thousands of people over the last four decades."

"My wife . . ."

Liz shook her head. "If he gets away with this, it will just be something else next time. We have to deal with it now."

"How? Peal's a master of robot technology."

Her mind suddenly clicked. "That's it! Mac . . ."

"What?"

"Technology. He'd look for a technological assault, not a physical one! I could offer to exchange myself for as many hostages as he's willing to let go. Once I'm in . . . he's low-gee soft and maybe thirty kilos overweight. I train to one gee. I could take him out with my bare hands."

The young medic looked aghast. "And maybe you'll get yourself killed! He has robots and the ability to get around the laws of robotics."

Liz nodded, almost surprised at herself. "He's got the project by the throat, and I promised I'd get it done. It's worth taking the chance." Liz stared at him a moment and made a decision. "Mac, can you give me an edge?" There was a drug, she knew, that would give a person "hysterical" strength, enough to lift beams off people crushed in a structure collapse, or pull open a locked door to safety.

"A gamma stimulant? They're illegal . . ."

"They're for emergencies. This is an emergency."

He tightened his lips, then said, "Okay, it's worth a try. You getting killed wouldn't put my wife in any more danger, and might get her out right away." He paused and nodded, apparently making up his mind. "Wait a moment. I need to get the drug myself instead of ordering it the usual way. Peal has probably compromised the system, and we don't want to make him suspicious."

The moment turned into several minutes—precious minutes in which either Peal or Gunheim might do something to make what she planned impossible. Finally, Mac returned. He held out a small blue capsule to her, and she took it in her hand. It stuck to her.

"Geckro surface. You can hide it in your mouth and it will stay put. Bite it hard when you need it. You'd better get going."

Liz nodded in acknowledgement. "Don't tell Cyan until I'm in." She turned and headed for the Canning base airlock.

Three hours later, Liz came through an airlock and faced Peal. She'd gotten seven hostages freed in exchange for herself—not as many as she'd hoped—before she went in. The remaining hostages were in the back of the lounge module Peal had occupied, normally a place for crews to take a break from vacuum work. It was essentially a spacecraft with everything but a propulsion system. The chunky, beady-eyed man stared back at her, his mouth set, looking for all the world like a rebellious teenager. A dull-finished utilitarian humanoid robot, anatomically correct in one important feature, stood quietly beside him. Peal's sick sense of humor, she thought. The hostages were in plain

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view sitting on a couch and chairs in the room behind him. The hostages weren't bound, but Peal had erected a transparent barrier between their part of the lounge and his. There were handcuffs on the table in front of them.

A hummingbird-sized robot hovered about her on nearly silent fans, undoubtedly probing for anything technological down to the size limit of autonomous robotics. Steady, girl, Liz told herself as she let herself be inspected.

"Okay, you pass," Peal finally said. "So here we have one of these would-be gods that want to play with universes! Do you feel godlike now?"

He wanted to humiliate her! Maybe she could play that angle. "Let these people go, please. Then I'll do whatever you want."

Peal laughed. "Really? Wu and Markovitch, get your suits on and get out of here. Simmons and MacGregor, you stay for now."

Mac's wife was a petite brunette, her face a mask of determined calm.

"Everyone, Peal. Please."

"No. I may want some more fun later. Are you going to keep your bargain?"

Liz bit her lip. She didn't want anyone else around but, she told herself, the gain was worth the risk. "Okay. What do you want?"

He leered at her. "Take your shipsuit off. Put a set of handcuffs on and come in here."

Liz complied. The handcuffs clicked ever so softly as she shut them around her wrists. The material felt like basalt fiber composite—the standard 3D lithography material. It was strong enough, but brittle, she thought.

When she got the cuffs on, a section of the barrier slid aside.

"Come in," Peal said with a grin. As she reached the opening in the barrier, the humanoid robot began to move toward her. "A modification of the virtual reality glove. What it feels, I feel. Now turn around. Do you know what 'black hole' means in Russian?"

Now or never, Liz thought. She bit down on the capsule as she complied with Peal's order, moving back against the barrier as she did so. She shivered to elevate her heart rate and hyperventilated. Strength flowed into her. Steady, she told herself, thirty seconds for maximum effect. She felt her muscles quiver in preparation.

"So you think you're going to play with the universe, do you?"

This wasn't going to be easy. Okay, she thought. She'd never get to Peal before the robot got to her, take the robot first. She allowed it to close the distance. Then, with a scream, she snapped her arms outward as hard as she could and fell back against the barrier. The handcuffs cracked open and the line holding them together pulled out of the right one. The pain was blinding but somehow detached from her. The robot snapped toward her almost faster than could be seen, but her right leg was already up to meet it. Her heel hit right in its mechanical pelvis, and she felt searing pain as something snapped in her leg. Damn, Hilda, I tried. I really tried, she thought.

But in a second she realized she wasn't done yet. The robot had rebounded from the collision and was sailing across the room in the low gravity. Before it could bounce and get back, she launched herself at the startled Peal, ignoring the pain in her leg.

No time for fancy stuff. Her balled fist caught him squarely in the jaw, going through it as if it were balsa. Her momentum crashed them both into the mini galley at the end of the room, a coffee pot bouncing away, spewing hot liquid all over. The impact knocked the breath out of her. Already she was beginning to feel lightheaded and tired; but the robot would be back for her. She whirled Peal's limp body around to put him between her and the robot.

The machine crashed into them and bounced away, inanimate.

Dead man switch? A look at what was

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left of Peal's head told the story. There was gray matter on her fist. She shook it off automatically, revulsed.

Boost and adrenaline spent, the pain from a broken leg and broken wrist hit her hard. She felt nauseated, and fainted. The last thing she remembered was the smell of spilled coffee.

When Liz regained consciousness a week later, her wounds were healed, she was a hero and Cyan Mutori was the new chief executive of the Campbell system. Roger Gunheim had left the Campbell system with DeRoot and some of their cronies, bound for the BHP vertex to see the implosion, and then onto a new colony at Stein 2051, twenty-five light years distant.

Chapter 5

In Space, at the Impactor Launch Site, 26 October 2275

The impactor looked like a long thin filament that seemed to run out to infinity. At high magnification, David could see a slight texture to it; individually controlled superconducting solenoid rings were placed every few meters to stretch the wire taut to just the right tension, giving it some rigidity for maneuvers and providing a fine control on its density. Somewhere, out there toward the end of the rod, was the main magnetic reflector. Any time now, David thought.

Cyan's term as chief executive had begun well. The impactor launch was back on schedule, albeit with the smallest of windows. No more delays could be tolerated, but so far, so good. He, Judi, Cyan, and Liz took a shuttle out to the launch site, a point, high over the asteroid belt, where the impactor coasted, waiting for the main beam. While far from the revelry, they had all wanted to, well, be there.

David wondered when they would see it light up.

As if on queue, Liz announced, "About now."

At the far distant end of the impactor, a tiny blue star appeared and gradually grew to an iridescent flower, brighter and brighter with its far edges fading into a deep violet.

In the close-up optics, the impactor began to move across the field of view. Faster and faster it went. The view zoomed back.

It was bright enough now that David risked a look at Campbell and the ring of beam projectors around it. Only a few of them were active at this early stage, he knew, but already the power was a million times that used to launch a starship. And it would grow by many orders of magnitude over the next nine months. By that time, he would be deeply into analyzing the results of the planetoid's impending impact on Martin.

He felt Liz's arms around him and smiled. Time enough for work later. Her face was glowing—he kissed her. Cyan Mutori glanced at them and looked away.

They watched for an hour or so, until the violet flower had faded into the interstellar depths. Then their shuttle turned back for Minot.

Once home, David put his full energies into his own projects. To the victors went the spoils, David thought. His work, which he'd worried about losing altogether, was now getting high priority; such was his reward for backing the winners.

An urgent message awaited him—results from his Prospector Probes deep in the icy mantle of Martin. They'd struck water. No question about it; 11.36 kilometers under the ice surface was a huge lake, filling the bed of an ancient caldera. No, he thought, not all that ancient. Martin must not be completely stone cold. There was some tidal stress from its eccentric orbit, and its radioactive ores still put out a fair amount of heat. It had to get out somewhere, and the readings pointed to several vents across the bottom of the lake. There

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could be life down there, he thought.

It hit him in the gut. Oh, God! If Martin had water and heat, then . . . his imagination ran wild.

Far from being the agent of a temporary rebirth of this planet, the impending collision might mean the destruction of one of the perhaps six independently evolved biologies known.

Liz stared up at the sky in her dome with restless anticipation. She touched the net to check the countdown . . . 1205013 seconds . . . about two standard weeks . . . the particle projectors would finish their job—and hers. Then what?

A beep on her comm sounded. A message from David in his new lab.

"Liz, come over, please. I need your help!"

She found him staring at a micrograph of a rock sample brought up from a deep borehole on the planetoid falling toward Martin. He hadn't noticed her coming in, but instead continued to stare at the dark rock. She found herself staring at it, too.

Liz saw a number of what looked like tiny microbes, squirming around. "From the planetoid?" she asked.

"Liz?" They kissed cheek to cheek, not on the mouth, Liz noted. He was all business.

"The center of the planetoid is now above the melting point of water. It would be boiling in a near vacuum; but here and there, the vapor can't get out fast enough, and the pressure rises to the point where liquid water exists. They thaw out once every hundred and eighty-three thousand years, and they're thriving, for the last time."

"In the wild anyway. What are they?" she asked.

"Archeae. Almost eighty percent identical to those in the Solar System and thirteen other star systems. Their cell membranes use left-handed glycerols, their DNA forms loops instead of the strings capped with telomeres that we use, plus some other things. They're rugged; that's why so many of them are extremophiles."

Liz looked at him quizzically.

"For one thing, their DNA doesn't wear out."

"Wow! Neat." She knew the whole astrobiology team was in a race to study every facet of the colliding worlds before the collision destroyed the planetoid and utterly transformed Martin as well.

"Expected. We find them on Martin, too, and on that planetoid you found back in the Solar System. But there is something else in some of the volcanically-warmed lakes on Martin: multicellular Archeae with knobby-loop DNA. See?"

Liz couldn't tell if the stringy stuff she was looking at were loops or not, but they appeared to have knots in them.

"God knows how long these little critters have survived protected by that layer of ice, Liz. We'll probably never know their earliest beginnings. What could they have shown us?"

Liz squeezed his hand. "I think they've shown us that life is everywhere."

He squeezed her hand back. "I need your help badly, Liz."

"How?"

"I know I was against changing the planetoid's trajectory originally. But I did not know about the knobby DNA then. We have to stop the collision."

"What? David? How? The BHP impactor needs the entire array output for the next ten days. And look at the simulations. Even if we were to turn the array on the planetoid now, without time for any preparation there's no guarantee it would accomplish anything."

"There must be a way! That is your field. Give us a chance to study Martin biology in situ!"

Liz shook her head. "I'm truly sorry, David."

He looked at her, anguish written all over his face. "That is all I get? 'I'm sorry?'"

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Liz felt torn. "David, my job is to make sure the impactor gets exactly what it needs. There are three other impactors headed for the experiment site. If any one of them is off, a half century of work goes down the drain. I can't think of anything we can do at this point that wouldn't jeopardize that. But I'll ask the staff. Anyway, the geometry is wrong; the planetoid's trajectory is in the local ecliptic plane, so half the array is blocked by the other half. The gap is on the one side, and Martin blocks the other side. We won't be able to get a significant push on the planetoid for another three days in any event. Maybe you'll have enough samples by then."

He abruptly got up. "I need a break."

She took his hand and held it tightly.

"Make it enough time, Liz, please," he said. "I am going out to the remote lab to do what I can."

Three weeks later, David greeted Liz at his remote lab deep inside the only natural satellite of Martin, and gave her a quick tour. The moon was a captured nickel-iron asteroid about seventy kilometers by fifty by thirty. Robots had hollowed out a 500-meter spherical cavity deep beneath the surface. They also built a rotating drum that was 200 meters in radius to provide enough gravity to keep the researchers' bones solid and to settle the various fluids of life in and outside the isolation lab. Construction was still going on, and people were working out of cubicles. Plantings and roofs would come later, he explained.

She looked grim and troubled, he thought—and steeled himself for bad news. He showed her a seat in a bare cubicle he used as a staff conference room. Cyan Mutori was on screen, seated with a couple of council members and three or four people he thought might be project engineers. Cyan looked as poised as ever, with no hint as to the position she might take. He took a deep breath.

Cyan started. "David, for those of us who are not exobiologists, perhaps you could start this conversation with a little background."

"Thank you, Cyan. We have found multicellular life on Martin. Worms actually, primitive, but with a pass-through tube for a gut and the beginnings of a primitive nervous system. We suspect there are more complicated life-forms."

The lightspeed delay between the lab and Minot was almost a minute. It seemed more like an hour. Finally, the people on his screen reacted with a murmur, but it was not as loud as he'd hoped for.

He tried again. "You must understand the importance of this. We have found the first multicelled life-form that humanity has ever found off-Earth."

Another minute, more murmur.

Cyan beamed at him. "David, this is great news, and your team is to be congratulated for all their hard work. Wouldn't everyone agree?"

Louder murmuring and congratulations poured toward him. "Could we have some additional perspective of your discovery?"

Gehenna. What else could he tell them? He spread his arms. "Look, it's a given that all the life we know spawned from single cells. That's the beginning. What we have here are multicelled organisms. So the problem to investigate is: Where did they evolve? Near the thermal vents at the bottom of the lakes on Martin, or somewhere else? And if so, why were they able to survive on this particular planet?"

Liz leaned forward. "These life-forms may have come from someplace else?"

He had expected his good news would set everyone's enthusiasm on fire. Instead he was getting polite questions.

"They have loop DNA like terrestrial extremophiles, but with these knobby kinks in it, so we aren't sure whether they are descended from Archeae. We could have another, entirely different architecture of life floating around the galaxy. But the gene trace diagrams indi-

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cate a recent origin, pointing toward a development unique to Martin. I'm betting that life for these worms started right on this planet."

Another wait, then someone else asked, "Have you looked into the geologic history of this planet enough to be able to substantiate this thesis?"

He shook his head. "We do not have data enough to decide one way or the other. We need more bore holes, more lakes, and more samples. We need an intact planet on which to do this."

"But we don't have the time," Liz said simply.

He shot her a look, then looked back to Mutori. "That's where you all come in. We have to divert the incoming planetoid. It would be nice if this could be done without affecting the Black Hole Project, but this has to take priority.

"Look, I've studied the project plans and there is some margin built in. The impactors lock into beacons as they approach the impact point and start exchanging vectors. They can all decelerate a little to recover synchronicity if one is a little off. We can make up the total momentum after diverting the planetoid and let the impactor control system get things back in sync again. But even if that doesn't work, would it really matter if it takes another century to make a black hole? This is something that may never come our way again."

Liz shook her head. "I can't endorse that approach. What if we aren't the only ones with some kind of problem? Yes, there is some margin, but not enough to cover things if all four impactors make changes as big as we are contemplating here. We can't just grab all the margin of error for ourselves. We have to put that impactor on exactly the prescribed profile if we humanly can."

After the lightspeed delay, a project engineer shook his head. "It would be better to destroy the impactor and start over again than to be slightly off. A great many things could happen with an asymmetric impact, some of them very dangerous indeed, and to people other than ourselves."

Cyan Mutori nodded gravely.

David's heart sank. They just couldn't see how important it was! Of course not, he thought. They were mostly physical scientists and engineers. They had different values. Against all logic, he searched Cyan's face for a hopeful sign, but her face, of course, gave nothing away.

There were more questions and answers, but in reality everyone was well informed. This was not a question of facts, but one of value and perspective. His, he realized, were not theirs.

One of the council members made a motion to adjourn without acting on the diversion proposal. They voted silently.

Finally, Cyan looked at him. "The consensus of the Council is to continue with the original mission plan. We'll put all available resources into getting as large a physical sample of pre-collision Martin as we can, right up to the last minute. I am sorry, David, but it is the best we can do for you. I know human team members will want to stay until the last minute, so we need to be fairly firm about getting them off. Please inform everyone that all human team members should plan to be off of Martin within twenty-four hours of impact, for safety."

David nodded dumbly and sighed. "I understand. Thank you for considering this. Since there is so little time, I should get back to work."

Liz went jogging. The track circled the small habitat—if you ran spinward you were heavier. She ran spinward—punishing her body helped with the frustration. They had enough power to divert the planetoid now, but no way to couple that power efficiently to the planetoid. It would require engineering a new reflector to couple the beam's momentum to the planetoid. But if they waited until they could get one installed, it would take so much power that the

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project would be compromised. The dilemma seemed to have no solution.

David, of course, would never understand that. Liz continued going in circles, mentally and physically. Finally exhausted, she stopped at the locker room, showered, dressed, and headed back to David's quarters.

David wasn't there.

David stowed his Martin suit and a big duffel bag behind a bulkhead, then geckroed his feet by the airlock as the last shuttle from Martin's surface docked. His course was settled, but he wanted to make sure no one else would be harmed. He waved to them as they came out of the access tube and pulled themselves down the corridor, accompanied by robots pulling bags of samples and gear. They all smelled of dust from the surface.

"Is everyone off the planet now?" David asked the last one off, a stocky man named Ned Oh.

He nodded. "Everyone's here and accounted for."

"Very good. I will try to get back before departure for Minot, but if not, go ahead without me; I may be some time, and can take this shuttle back."

Ned looked at David oddly, then smiled. "You? Late?"

David forced a smile. "The collision apparently will *not* be late, and there is still much to do."

Ned patted him on the shoulder; the lack of an effort to divert the planetoid had been a downer for all of them. They shook hands, and Ned followed his group down the corridor.

David boarded the shuttle and stowed his gear. Settling at the controls, he contacted the busy port manager. "I need to make a fast trip down to the surface. There is a last minute discovery at a new ice lake."

The man, tall and light haired with a bushy mustache and an easygoing manner, squinted and smiled. "Well, now, someone might think you just wanted to be the last one off the planet."

David smiled back nervously and didn't say anything. Let him believe what he wanted.

The man shrugged. "Okay, it's fueled and ready. No other traffic, so you're cleared."

The trip down to the planet took four hours. The ice lake actually existed; he landed on its shore. If nothing else, he would find out one or two more things about this world. He pulled one of two boxes out of the duffel bag and replaced it with a survival tent and a couple of days' worth of rations. He carried the box down the ladder and set it down outside the shuttle's airlock. Then he went back up, opened the panel to the ship's main processor, and disconnected it. That should set some alarms going, he thought.

On his way out, he touched the box and hesitated, going over everything again. No, he had to do it this way. There could be only one way to get him off the planet alive, and that would be to divert the planetoid. He took a breath, threw the switch on the timer, climbed down the ladder, picked up his gear, and headed for the lakeshore.

Ten minutes later, the blast severed his only way off the planet.

They had not really listened before; perhaps they would listen now.

Later, on a small rise, he looked out over the lake. At early evening by local time, the scenery here, in one of the few places on Martin's surface not covered with ice, was breathtaking. The steep sides of the caldera were a study in deep red and black, with glints here and there of volcanic glass. The ground was cracked and brittle—he would have to watch his step; getting himself killed too soon would defeat the whole purpose of this mad exercise.

Would Liz or Mutori pull out the stops and divert the planetoid? Or would they let him be blown to smithereens along with the planet? He looked at the still lake, reflecting the glowing crags of the

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caldera's rim. Was it really still, he thought, or was it, too, teaming with life, every bit as deserving of saving as the damned, all too important, Black Hole Project?

Liz was deep in concentration on an idea that just might work. Array construction robots in orbit about Canning were hurriedly fabricating a huge net, a thousand kilometers in radius. A large magsail, meant for a starship, would be attached to the net, along with several million tons of ballast weighted around the rim of the net. If everything went right, the whole assembly could be pushed with planetary transport beams to intercept the planetoid about a hundred planetary radii from collision with enough momentum to cause it to graze Martin's atmosphere instead of colliding directly. But it would be very, very close.

Something was trying to get her attention. Amongst the numbers and trajectories, a signal light was flashing.

"Yes?"

"It's Ned. I'm at the door. I thought I should deliver this news in person."

That didn't sound good. "Come in."

One look at his face confirmed that he was the bearer of bad news.

"Liz, have you heard about David?"

She shook her head.

"He's gone to the surface of Martin, making a human shield out of himself."

"Oh . . . crap! I'm sorry, I should have seen this coming. He's never . . . he . . ."

"I didn't see it coming either."

"I'll need to talk to Cyan."

Ned nodded. "Let me know if there's anything I can do."

As he left, Liz touched the net. *Cyan, emergency, Cyan, we have a problem,* she sent. The lightspeed delay was maddening.

What, Liz? What is the matter?

David has gone human shield on us.

Wait.

Human shield?

He's gone down to Martin in hopes that we'll divert the beam projector to save his life.

Wait.

You know him better than any of us, Liz. Can you talk him out of it?

I'll do what I can. I'll get absolutely nowhere talking on the radio. I'll have to do this in person.

Wait.

The momentum exchange mesh—the big net—is almost ready, Cyan said. *Hopefully we can spread the push over the entire area and hold the major pieces together. If we use BHP projectors, we can load less ballast and launch it now, then give it a major push.*

No! Keep the project projectors on the impactor. We can't risk screwing with that. I'll go down to Martin myself and try to bring David back.

Wait.

Liz, do you think that is wise? Much could go wrong.

Liz remembered how David had helped her stand up to DeRoot, how he'd been at her side when things had seemed darkest, and all the wonderful, sweet moments of lovemaking they'd shared.

Cyan, I owe him too much. I have to try. I'd never forgive myself if I didn't.

Wait.

I understand. You will take several robots, of course, armed with tranquilizer darts; I will authorize the exception to the Asimovian rules. I know you will try to get his voluntary cooperation first, but time is short. And Liz, we've been over David's recent communications. Voice stress analysis, word patterns, and other things. He doesn't seem to be well.

Chaos! What?

People still occasionally got brain tumors, Liz knew. They were quickly cured when detected, but they had to be detected first. Then there was the stuff he was working with; the quarantine was very good, and the human immune system should be totally lethal to anything that hadn't evolved ways to

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counter it. But there was still a chance. Deep in thought, Liz barely noticed the lightspeed delay.

We don't know without doing a scan and taking samples—it could be strictly psychological, stress induced. But I think it's important to know if he's been affected by anything in the environment because a layer of that environment will be plastered all over this planetary system in a few years as a result of impact debris. At any rate, there may be some pathology involved; he's not acting rationally. Also, whatever he does, you should not blame him, or yourself. I know this is hard when it happens to someone you love, but tragedies happen. If the worst happens, remember him as he was. Finally, and I am very sorry to say this, but he may strike out irrationally. Remember that if he does, it's not him. But still, be very careful. And remember that it is not always possible to fix everything. If it gets too late, come back.

I will, Cyan. Thank you.

Could she hunt down David as if he were a zoo animal out of his cage? Could she leave him to die? Did she have any choice?

David found that he was off the net. The relays might have been removed or someone might have thought that denying him access would give them an advantage. That meant they were going to try to resolve this by force instead of negotiation. His heart sank; that would cost several hours. No, he thought, they might work the problem in parallel; even now some way to divert the planetoid might be in the works, something that could be turned on or off at the last moment.

Night fell. The planetoid was less than a day away, near the ecliptic plane, coming posigrade. He looked to the west and found it easily—it had a huge coma of gas, like a comet. The nucleus was already a small disk. It would stay there, fixed among the stars. That was how one could tell if something was going to hit you—the angles stay the same.

Very well. If they were going to try to force him off, they would come with robots, sensors—the whole nine yards. They would succeed, unless he could somehow anticipate them and strike first. He had dealt with terrorists back in the Israeli defense force; he was on the other side now, but he knew the territory. Maybe they would not anticipate that.

To get a surprise, he would have to make them think he was here but actually be there. He took a reflective blanket and some line, then climbed up a small lava dome until he could see the landing site. He built a couple of small towers with flat volcanic rocks and anchored the top of the reflective blanket to them. Then he anchored the bottom of it at about forty-five degrees so it formed a kind of lean-to. He went back down and moved his campsite until he could see the distorted reflection of the still-glowing wreck of his shuttle in this jerrybuilt mirror. The radio in the emergency stores had both infrared and radio frequency bands, as did the suit. He set it up in sight of the mirror. If this worked, he'd be able to speak on infrared from his suit, the infrared would reflect off the mirror to the emergency comm pack, and his voice would come out on the radio from the campsite.

He took a second box from the duffel bag and headed for the landing site.

Halfway there he keyed the infrared channel in his helmet. "Hello, everyone. Liz, Cyan. You know I am very sorry to cause you so much trouble. You must also know that this is more important than your inconvenience, or even my life, if it comes to that. You must do what you can to prevent the impact. I must do everything I can to make you do that. I have no choice in this. I hope you understand this. I am sorry."

He heard his little speech on the radio as he said it; a distracting echo, but it proved his system worked. Unless they

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had managed to deploy a very sophisticated surveillance system on very short notice, they should think he was at the camp site on the shore of the lake; he'd left a heater on there, and the radio would be coming from there.

"David, this is Liz. I'm coming to get you. We've figured out a way to divert the planetoid; a huge mesh net is on its way from Canning. It will probably work, but if the planetoid breaks up in the net, some of it may get through. It's too dangerous to stay on the surface of Martin."

David's heart beat rapidly. There was hope. Then he thought again. What proof did he have that anything was actually being done? They'd cut him off the net. She could be lying. Why not? She would do anything to save her damn project.

"Liz," he said. "That sounds very hopeful. Thank you for making the effort, if it is true. But I must take the risk that it is not true or I give up all my leverage. Please go back and get me after the impact is diverted."

"David, you might be dead!"

"I know this. I have thought this through very carefully. It is my choice."

"David, I am coming to get you. That is my choice."

He could think of nothing to say to that. He quickly covered the distance to the landing site and hid himself in a broken lava tube near the wreck. None too soon; just as he settled in, he heard the sonic boom of the approaching shuttle, and soon the glow of its engines lit up the landscape. He watched the bullet-shaped vehicle's landing gear extend as it set smoothly down, the hatch side turned mostly toward him.

David agonized. But he would have to do what he had to do; he had come too far to waver now. If Liz was lying to him, she had sealed her own fate as well.

As soon as the shuttle landed and Liz had popped the hatch, he opened his comm line. "Liz, my camp is on the shore of the lake, about ten minutes walk from here, uh, I mean from where your shuttle is coming down."

"I see it, David. Please come meet me at the landing site. We're doing everything we can."

He shook his head automatically, even though she couldn't see him. "I cannot take that chance. I am sorry. If you want to talk, come to the camp. We still have several hours."

Liz didn't answer him. The hatch swung open and she descended, followed by three black circular robots hovering on their fans. He could barely see them, but this close he could hear them.

She strode off toward the camp, her path lit by a helmet light. The robots, presumably invisible now, followed. He patted a device in his pocket; he had an answer for those, but now was not the time to reveal it.

David judged the distance to the shuttle. He didn't dare use the infrared to talk now; Liz would pick that up in her helmet and immediately know what he was doing. Would she suspect? Had she left a guard? The best strategy would be to approach the shuttle normally. His box with the bomb was a standard sample box and should be recognized as such.

He waited until she was halfway to the camp, then got up and walked as calmly as he could to the shuttle. He opened the standard infrared channel for robotic interface and positioned his body so the beam would not carry to Liz or his own radio relay setup, he hoped.

"Hello. I'm David Levi. I have some samples to go to the lab."

"Mr. Levi. Please do not enter the shuttle; you are not authorized. I have notified Captain Avonford of your presence."

"David!" Liz screamed. "I thought you were at the camp. What are you doing at the shuttle?"

"I changed my mind," he said, using the radio channel from his suit. He took two more steps closer to the shuttle,

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reaching the right landing gear. "I really wanted to see you again, Liz."

He turned away from the shuttle, triggered the switch and set the sample case down as carefully as he could. He started running toward Liz, not daring to look back. Five . . . four . . . three . . . two . . . one . . .

The blast wave almost knocked him over. Now he looked back and watched the shuttle topple to the ground. Back to square one, he thought. He turned back toward Liz and stood motionless, trying to figure out what to say. She would probably be upset.

A sudden sting in his arm told him just how upset.

Liz had skimmed along the regolith toward David, wanting to believe him, wanting to get him and get out of here. But she'd been deceived. Should have had the robots tranquilize him earlier, she thought. But she'd held back. Maybe there was an explanation that made sense. Once he was in her arms again, surely he would listen to reason. He had run toward her; she could see the light on his helmet bob up and down with each long stride. Surely they could still sort things out.

The blast took her totally by surprise, and she watched in horror as the shuttle toppled to the ground. There was no second explosion, and its navigation lights stayed on. The port light created a pool of red on the lava and showed the crumpled side of the vehicle in high relief.

Liz brought herself to a halt. *Take him down,* she sent to the hovering robots. Talk about closing the barn door after the horse escaped.

Liz, Ned. Are you okay?

I'm fine. He got the shuttle before I got him. Can you get another one down here?

We'll have to try, won't we? The port manager and I've got it in works, but it looks like an hour to fuel and check out and four hours—make that four point three—down to the surface where you are. That's collision time, I'm afraid.

Her heart skipped a beat and a knot suddenly tightened in her gut. *Chaos, try to shave ten minutes off that somewhere, will you?*

I'll try my best. Do you want me to tell Cyan?

So it's down to this, Liz thought. What would Cyan Mutori do? A word from her now, and the full power of the beam could be thrown against the planetoid, possibly breaking it up, possibly pushing it away. But that diversion would also throw the impactor off profile, perhaps irretrievably so. Damn Peal! There was no margin, none.

Not just yet. See where you get on the spare shuttle.

Are you sure, Liz?

It could mean the difference between probably living and probably dying, for both her and David. But it could also be the difference between carrying out her mission with certainty and leaving humanity's greatest project to chance. She'd wanted to be the big fish in the small pond, to have the big decisions. Well, this was one that would echo through the rest of history.

Yes, I'm sure. Ned, if it doesn't work out . . . It's not your fault. But get that damn shuttle here!

As soon as we can. Good luck. Ned out.

Liz looked up at the oncoming planetoid and its halo of gas, rising high over the eastern horizon. It would not, if she remembered the simulations correctly, quite reach the zenith from her location. In the last minutes, it would begin plunging back down to the horizon. Then a hypersonic detonation wave would jet out above her, and the blast wave would roll over the horizon at the local speed of sound, some twenty minutes later.

Human beings had voluntarily gone to their deaths before, for a big enough cause, but she had not ever quite

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thought of herself that way. She'd survived everything so far, on sheer strength of will. We were out here because of will, she thought. The shuttle would make it.

Liz, Cyan. What's going on down there?

Liz sighed. It hadn't taken her long to find out.

A small delay. He's tranked now. I'm going after him.

Wait.

You are stranded!

Maybe. Cyan, am I still in charge? Is it my call? You know what is at stake. This situation is my responsibility, and I have chosen to keep the project on profile. On our friendship, please honor that choice.

Wait—this time much longer than required for just the lightspeed delay.

I understand what is at stake. If it were my responsibility, I would, I hope, have the courage to choose as you have. But we will do everything we can short of affecting the project to get you out of there. The net has been launched; it should arrive three hours before impact. The planetoid will still be half as far away as the moon is from Earth. If everything holds, it should get enough delta-v to just graze Martin's atmosphere. Roche forces will pull it apart, but the net may hold it together for a while. We can't tell whether it will be captured or not—too many uncertainties.

You're giving me some hope, anyway. Between that and the relief shuttle, I'm going to assume I'll make it.

Liz had kept walking as she talked. David's helmet light glowed softly, nearer and nearer.

When she got there, that was all there was—the helmet light.

Where's David? she asked the robots.

The one designated "Alpha" answered. *We have a command authority conflict.*

"Chaos!" Liz struggled to regain her temper.

Cyan, could you reset the command authority override on my robots? David has pulled another fast one on me.

Wait, agonizingly long.

Done. Use the prefix "Sunbeam" if you have any more problems.

Thanks.

To the robots: *Sunbeam. Where's David?*

Mr. Levi is proceeding on foot to the lake. He apparently has a trank antidote.

No kidding! Keep him in sight. I'm following.

Liz, Cyan. We can still boost the net a little more.

Chaos, Liz thought. Why couldn't they just let the decision stand?

No, Cyan. Thank you but no. The whole thing's chancy and the last thing I'd want is to screw up the project, and *get killed, too.*

Wait.

Liz! Judi Lalande broke the quiet. *In one hour, we can no longer accelerate the net. Martin's moon is getting in the way.*

Yes, Judi, Liz here. I understand. I may end up seeing this explosion firsthand. You know what? I'm not scared. It's like letting go. Liberating in a way. What will happen will happen. I accept that. Just get that shuttle here!

Silence. It gave her a momentary chill. Would they respect her wishes? She tried to contemplate her humiliation if they did not and the project got screwed up. She smiled to herself. Risky behavior was nothing new to her, and here it was, the ultimate. Triumph or die. Or triumph and die. Either way, glory.

As if floating on air, Liz started running toward David. There was still time to grab him and at least get away from Martin.

She stopped bouncing and opened a radio channel to David.

"David. What's going to happen is going to happen. There's nothing more

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that anyone can physically do. The net is on its way; we should be able to see the intercept. It may work. Meanwhile there's a crewless shuttle on its way to take us off. It may get here in time even if the net doesn't work. There's no point in running from me anymore."

"I cannot believe you."

Liz looked up into the sky and asked for a reticular circle where the net was. It floated in front of her eyes at infinity, a faint red circle. There, in its center, was a tiny spider web.

"David, believe your own eyes then. Look up, in Ursa Major, a little left of Mizar and Alcor, there's a faint, tiny web."

It grew even as she watched. Liz touched the net. Forty minutes until impact. Even without additional boost from the project projectors, the device was traveling at a hundred and thirty kilometers a second.

Maybe too fast, she realized. She looked at the projections; ninety percent of the net cords were predicted to fail on impact. Would the remaining ten percent be enough? Things would stretch, of course.

David materialized from the dark into the glow of her helmet light. "You planned it this way, didn't you! You all did."

Liz didn't bother to answer that. He was here; that was all that counted. "You're not thinking clearly. Let's get to the shuttle rendezvous."

David caught up to her and they both turned toward the dark sky standing side by side. "When?"

"Thirty minutes for the net impact, about three hours for the main event and the shuttle landing."

Wordlessly, they headed for the landing field, about three kilometers away.

The net zoomed by overhead, moving at the apparent rate of a high altitude aircraft or a satellite; but it was much farther away and moving much faster. As it approached the planetoid, its angular rate grew less and less; a trick of perspective, Liz realized. The net now moved almost directly away from them. It would have been better, she thought, if it could have hit the planetoid from the side, but this would be almost as good. It only had to slow it a little, just enough for Martin to move a little farther from under it.

The net vanished, invisible against the glowing gas surrounding the planetoid.

It happened slowly. The planetoid slowly split into two, then three, then five pieces. Some of them seemed to be drifting off to the right, others not at all.

Liz, Cyan . . .

I saw, Cyan. It looks like part of it is still going to hit.

Wait.

Yes. There was a small delay on the shuttle trajectory to let the net go by. It will be very close. Be ready to run for it. In the meantime, perhaps you would wish to settle whatever you need to settle. I've opened the net back up to David.

She didn't think they would make it. *Thank you, very much, Cyan, for everything. Thank you.*

Two hours, forty minutes. A message to Mom, of course. *To Captain Katherine Avonford on whatever starship she may be flying to wherever. Mom. You've probably heard what happened off the media. By the time you read this, I will have become so much interstellar gas flowing out of the Lacaille 9352 system. Perhaps we will run into each other. I'll say something general about how I feel about this—it's not really bad at all. I've let go. I'm accepting it, at peace with it, even in a strange way, looking forward to the experience. I always wanted to be important, to make a mark, to be remembered. But I'd rather have stayed around for the party. I forgot how so many of history's legends bought fame with their lives. Martyrdom isn't worth it. Tell everyone that. Martyrdom isn't worth it.*

And to Hilda. *I made a mess of it, Sis,*

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but I got it done. Enjoy the physics.

And to so many others.

She looked at David, silent, concentrating on his own good-byes.

They reached the edge of the landing field.

Five minutes. Death hurtled toward them. It was huge now, a constellation of comets with a single coma falling toward the horizon, visibly moving, passing what brightest stars still shone through its vapors. One by one, they slipped below the horizon.

Time to impact?

The first contact has occurred.

A sudden glow lit the horizon. Then a ghostly curtain began to spread from some point below it, like an aurora, but a thousand times brighter. Jets of debris and gasses tangent to the globe of Martin at the impact point moved at tens of kilometers per second.

Heart in her throat, she sent a last message to Cyan. *I guess this is it. Thanks for trying.*

Wait.

Hang in there, Liz. The shuttle's almost down and it will take several minutes for the blast wave to reach you. But be ready for five gees flat on your back in the airlock.

Shuttle on approach, be prepared to board.

She looked up and the deep blue of its jets lanced down from the sky. She reached over and grabbed David.

"Time to go."

"Go yourself. It's hopeless."

"Come on, we've got to try."

While David lingered in awe of its horrible beauty, Liz grabbed his arm and gave it a tug.

"Come on! Run for the shuttle!" It settled down fifty meters from them, its hot exhaust flapping their Martin suits.

She felt David pull her hand loose. "Go," he told her. You can't save this place, you can't save me." And he pushed her toward the shuttle. "Just go!"

It was futile, they both knew it. Regardless, Liz focused. She could not give up completely. How close could she come to getting away?

Prepare for immediate lift off as soon as I get in the hatch, she told the shuttle. Without David's weight, she reached the shuttle as the debris curtain spread overhead. The trick would be to get between that and the blast wave.

The ladder hung out of the hatch. David got up at last, and tried to run toward her.

"Hurry!" she screamed.

He tripped over a small rock and fell. He picked himself up. A second lost. "I'm going to be the martyr here, Liz. Get lost!"

A strange orange light flooded the horizon. She turned. Ah, yes. This was it. She sent what she saw streaming into the net. Roiling clouds zoomed toward the zenith as if in a time-lapse video of normal weather. It glowed. Everything glowed. She felt like she was in an oven.

Air slammed into her and sent her skyward, the shuttle and David tumbling nearby. She felt surreal.

Hot—very, very hot. Her visor melted, bowed in, a blowtorch played on her face. Everything went dark. She took a last breath, a breath of pure fire. She willed herself to take it deep, so as not to prolong the pain. *So I pass into legend.* ■

(EDITOR'S NOTE: Other parts of the Black Hole Project were described in "Kremer's Limit [July/August 2006] and "Imperfect Gods" [December 2006]. You can see additional information about the Project and the people involved in it on the "Science Behind the Story" section of the Analog *website [www.analogsf.com].)*

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A Madman Dreams of Turing Machines, Janna Levin, Knopf, $23.95, 232 pp. (ISBN: 1-4000-4030-2).

Mathematicians in Love, Rudy Rucker, Tor, $24.95, 364 pp. (ISBN: 0-765-31584-X).

The Android's Dream, John Scalzi, Tor, $24.95, 396 pp. (ISBN: 0-765-30941-6).

Alphanauts, J. Brian Clarke, Edge (www.edgewebsite.com), $14.95, 325 pp. (ISBN: 1-894063-14-7).

The Elysium Commission, L. E. Modesitt, Jr., Tor, $24.95, 336 pp. (ISBN: 0-765-31720-6).

Dadgum Martians Invade the Lucky Nickel Saloon! Ken Rand, Yard Dog Press, $14.00, 195 pp. (ISBN: 978-1-893687-81-3).

New Dreams for Old, Mike Resnick, Pyr, $15.00, 419 pp. (ISBN: 1-59102-441-2).

Notes for a Memoir on Isaac Asimov, Life, and Writing, Janet Jeppson Asimov, Prometheus, $25.00, 207 pp. (ISBN: 1-59102-405-6).

It is a cliché that madness and creative genius go together. Those who favor it often mention Van Gogh as a prime example, but creative people in many areas seem to strike ordinary folks as at least weird and at most dangerously warped, perhaps mostly because they think unusual thoughts and display a tendency toward extreme focus on those thoughts, bordering on obsession. We can see this in artists, poets, writers (including SF writers), and scientists. We also see it in the efforts of the mad to justify their madness ("I'm not crazy—I'm a genius!"). Add to this that people love to gossip about others who are in some way out of the ordinary, and perhaps you have enough justification for a public obsession with the madness of creative geniuses.

So why does most of the obsession in recent years seem to focus on mathematicians? I think of Sylvia Nasar's *A Beautiful Mind*, about John Nash, whose madness was schizophrenia. And now we have Janna Levin's **A Madman Dreams of Turing Machines**. Levin is a professor of physics and astronomy at Barnard College of Columbia University. Her obsession here—or, to be more fair, the obsession of her narrator—is with the lives of two men whose ideas have done an enormous amount to shape the modern world. Alan Turing played a seminal role in the development of computer science. Kurt Godel demonstrated that any system of thought (such as mathematics) must contain truths that cannot be proved from within the system (often misunderstood as just "truths that cannot be proved"). Both men are often mentioned as examples of high-achieving autism or Asperger's Syndrome. Asperger's, marked by social incompetence, repetitive behaviors, and often high intelligence, is sometimes called the "geek syndrome."

But Levin does not mention autism or Asperger's. She—or her narrator—begins by saying "The unsorted catalogue of biographical facts provides nothing without stories with their dents and omissions and sometimes outright lies to create meaning . . . Because some truths can never be proven by adhering to the rules." A Godelian notion, of course, and the reader is left to wonder what is truth, what is a lie in the pages that follow (with a bit of help from the Notes at the end), beginning with Wittgenstein and the obsessive mathematicians and logicians of the Vienna

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Circle, where the extraordinary Godel, social misfit and food-obsessive, introduced his great insight. Then to England, where young Turing is being mistreated by his schoolmates and displaying his own food obsessions ("He likes his food smooth") and his fixation on a classmate. And on Levin moves, focusing more on the two men and their madnesses than on their work, building a sense of time and place, and moving with a sense of inevitability toward their deaths, Godel by self-starvation, Turing by cyanide (after his trial for gross indecency or homosexuality).

The tale is quite modern in its self-referential character and lack of plot external to the characters' lives. It is more interesting than many such novels because Turing and Godel are interesting characters, and Levin handles them deftly and sympathetically. I found *A Madman Dreams* very readable.

But *A Madman Dreams* is science fiction only if you include fiction about science and scientists in the definition. I'm willing to do that, and if you share that willingness, you should enjoy the book.

Rudy Rucker is a mathematician and a highly creative SF writer. Is he crazy too? After considering *A Beautiful Mind* and *A Madman Dreams of Turing Machines*, one might think so. Madness is a perfectly natural state of mind for such fellows, right? But Rucker saves the madness for his fiction, and indeed Roland Haut, thesis adviser to math grad students Bela and Paul, is pretty far around the bend. Why, he sees giant cone shells floating outside his office window! You might wonder about Bela and Paul too, for their theses involve a theory that permits prediction of events from such things as the splash of raindrops. Paul's an orderly fellow, so he writes down his math as neat rows of symbols. Bela's more artistic, so he envisions the math as teapots, cakes, fish, and rakes. And when Bela insults Haut on camera, Haut kicks him out.

Poor Bela. He has a mathemagical mind whose visions sound like '60s dope dreams. He also has a new girlfriend, Alma, who needs a place to live, moves in, and starts acting interested in Paul. Of course, **Mathematicians in Love** act just as numb as anyone else, so it isn't long before tempers are a bit short. Fortunately, Bela is brainstorming like mad and finally proving the great theorem. He and Paul write the paper, add Haut's name as coauthor, and graduate. Paul moves out and takes Alma with him. Bela starts having trouble finding a job and no trouble at all finding trouble. Fortunately he's a musician too, and before long he's famous. But what he really wants is Alma.

All worlds have politics. Before long, Bela and Paul are being enlisted in a corporate-political scheme to use their math to make devices that will help a certain party (there's a pretty explicit analog here) take supreme power. That's when they find a way to tickle the device with an irresolvable paradox (shades of Godel!), open a hyperdimensional tunnel, and flee to another world where they find . . . Giant talking cone shells. Giant talking cockroaches (sort of). And a jellyfish that creates worlds the way poets write poems, each one better than the last.

Will the jellyfish create a new Earth where Bela can have Alma back? Can a world contain more than one Bela, Paul, or Alma? If not, who dies? Or as so many fairy tales have asked, what is the price of a wish?

Right on page one, Bela tells the reader that his tale begins on another Earth and ends on ours. When the jellyfish comes in, creating worlds in an ever closer approach to perfection, the reader must smile and perhaps anticipate the tale's penultimate punch line and wince a bit at the thought that our world, as messy and imperfect as it is, is the best of all possible worlds. Yet that thought is not unusual for Rucker. For all the weirdness of his fiction, he seems an essential-

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ly benign fellow, well pleased—despite the need of sundry groups, governments, and parties for criticism and satire—by the overall tenor of life in this world. Yet he is not usually so explicit. His benignity now comes across as a bit Pollyannaish, though if that's a flaw, it mars only the last page or two. The rest of the novel is as weird and wonderful as anything Rucker has ever written.

John Scalzi departs from his Old Man's War novels with **The Android's Dream**, a fun tale frankly inspired by Philip K. Dick, but going off in a much more rational, if still wacky, direction.

Earth, new to interstellar civilization, has as a chief ally the Nidu, the interstellar equivalent of a third-world country. At the moment, the two are in the midst of trade negotiations, but Earth's chief negotiator has a long-standing grudge against the Nidu, and when someone offers him a way to strike back, he grabs it. Even if . . . Well, the Nidu are caste-ridden and the high castes use odors to communicate. An Earth faction that wants to disrupt relations has come up with a gadget that, powered by intestinal methane and controlled by a wireless link, can emit deadly insults. It's quite inconspicuous, too, since it is implanted in . . . You got it. It works very well, too. The Nidu negotiator has a stroke and dies. The human conveniently has a heart attack in his moment of triumph. And the Nidu are furious.

They're also feeling frustrated. A coronation is coming up, complete with rites that demand the presence of a bright blue sheep of the very special "Electric Android" breed, ownership of whose genome was given by Earth to the Nidu. Unfortunately, the flocks, both on Nidu and on the human colony world where the breed was engineered, have been destroyed by a plague. The Nidu regime is in danger. If Earth's government can come up with a suitable sheep, then maybe there will not be a devastating war.

Enter Harry Creek, heroic survivor of a war that amply demonstrated the way the Nidu treat enemies and even bystanders (it ain't pretty). He's also an ex-cop and a grand hacker. A friend in the State Department, Ben Javna, hires him to hunt for the sheep, and he makes rapid progress, quickly learning that someone is destroying potential targets before he can get to them. But with the help of a unique AI, he finds Robin Baker, a pet shop owner whose DNA is 20 percent "Electric Android" (I won't tell you how; Scalzi does fine). Since the sheep-killers are right behind him, now the chase is on, with action that fits very well with what you might expect from the author of *Old Man's War* and *The Ghost Brigades*.

Enter also the Church of the Evolved Lamb, derived from the desperate poetry of a drunken SF writer and con artist who thought founding a religion would be a great way to make money. The religion turned out to have a life of its own. Now it forms a faction in the tale, as well as a deep and far-reaching conspiracy. And when Scalzi reveals that any Nidu clan—anyone, actually—that can come up with an "Electric Android" sheep during the coronation ceremony has a chance to supplant the clan currently in power, the Astute Reader gets a hint of where he's going. All that's left is the fun part, the details, and the biggest question of all: Will Robin and Harry ever have a second date?

This is one I stayed up late to finish reading. Not many make me do that any more.

J. Brian Clarke has appeared often enough in this magazine to be familiar to most of you. Indeed, his stories "Return of the Alphanauts" (1990) and "Adoption" (1992) gave rise to the novel at hand, **Alphanauts**. Unfortunately, he strikes me as stronger at shorter lengths. *Alphanauts* is an episodic tale that, while mildly interesting, breaks no new ground for experienced SF readers. It is most suitable for young (middle school)

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readers.

The tale begins when Earth's first interstellar explorers return from Alpha Centauri, where they found a habitable world. While enduring three years of quarantine, they learn that people who are too long away from Earth have a way of going berserk. It doesn't seem to have affected them, but when they visit Earth at last, it does. Have they transferred their internal "allegiance" to Genser's World? Then they must return, with others, as colonists. Once there, they soon discover a colony of aliens and their ships—still occupied by cyborg intelligences—and empathic "catbird" symbiots. In due time a ship arrives from Earth a bit ahead of schedule and proudly announces that it has licked the FTL problem. Then the signals from Earth stop. Since the colonists have FTL, they return to find disaster and discover that a ship loaded with would-be dictators is on its way to Genser's World.

It's not really a reviewer's place to tell a writer how he or she should have written the story. But calling a novel only "*mildly interesting*" is the sort of thing an author might well find insulting. So what would it take for me to retract the insult? Characters could be much more fully developed. Clarke could refrain from short-circuiting or leaping across (in the gaps between episodes) potential conflicts. Problems could resist solution more realistically and thereby contribute some dramatic tension to the tale.

In his "ghost" novels (and elsewhere), L. E. Modesitt, Jr., has displayed a fondness for heroes with military backgrounds who work in intelligence, academia, and/or research of some sort. The pattern holds in **The Elysium Commission**, which begins when private researcher and problem-solver Blaine Donne is approached by a client who wants him "to discover and ascertain in evidentiary terms the exact relationship between Eloi Enterprises, Judeon Maraniss, and Elysium."

Donne is a war hero whose current hobby is being the "knight of shadows," who prevents crime in the streets. His world is Devanta, ruled by the secretive Sorores and nervous about the tendency of the interstellar ubergovernment to disruptive, cataclysmic intervention when it decides a local government is too repressive. Eloi Enterprises, run by the ruthless and violent Eloi brothers, is dedicated to pleasures of the flesh. Maraniss is an arrogant, unsympathetic, and vindictive city planner who—the cover blurb reveals this much—has created a pocket universe containing a utopian city. As the story develops, the reader learns that he and the Elois are the heart of a conspiracy that involves interstellar politics, powerful enemies, and a pathological yearning for vengeance on the Sorores and their society. But Donne does not know this. He can only search Devanta's databases for connections, find a secretive research compound, massive energy use, and a movement of Eloi personnel offworld, be noticed, and survive violent attacks. He must also work on other cases, discover that his sister's business partner, Siendra, is both helpful and appealing, and in the end discover that everything is astonishingly connected, that the Sorores have a pretty good idea of what is going on and how to handle it so the ubergovernment doesn't step in, and that Siendra is much more than she at first appeared.

The finale is a satisfying flurry of extreme violence and a happy clinch. As usual, Modesitt leaves behind a very contented reader and a hope that he doesn't plan to leave Blaine and Siendra alone for too long.

Ken Rand tries too hard. He's sending too many things up at once—westerns, alien invasions, excessive use of dialect and malapropisms, and more—and while he can make the reader smile from time to time, the overall effect is more wearing than amusing.

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The opening scene of **Dadgum Martians Invade the Lucky Nickel Saloon!** is, of course, said saloon, located on Second Ave., Laramie, Wyoming Territory. The saloon's "regulars"—and Rand misses only one "regularity" joke—are bemoaning the end of barkeep Mick's (he's Irish, of course) generous credit policies at the insistence of his affianced, Miss Emma, who resides behind the red light at Miss Dolly Dubois' Residence for Refined Ladies. Journalist Sam Somebody (Clemens, maybe?) is taking notes. And that's when Casper walks in with a chicken on his head. Not just any chicken, of course. It has lips instead of a beak (which makes it lisp as well as replace the "cl" in the typical chicken noise with "f"), it wants a drink, and it says so using Casper's vocal cords. You see, when it's asetting on a guy's head, it can work him like a puppet.

It doesn't take long for the picture to clarify. The chicken is an escapee from a Martian scout ship, and the regulars soon decide that if they can sell it to the circus (in town at the moment, of course), they can solve the credit problem. They're chasing it around the bar's rafters when Jack arrives with a dead chicken snaffled from the whorehouse's henhouse, and a posse of whores, armed with rolling pins and surrounded by a cloud of lavender-scented pink powder, hot on his tail.

Pretty soon, the barflies are rescuing the alien pseudochicken from the henhouse at the cathouse and fleeing into the countryside with the whores whooting and whollering behind them. Soon rescued by the circus strongman and his mermaid wife, they wind up in control of the Martian flying saucer and crash the circus, in the process goosing the elephant into a pachydermatous tizzy.

You get the idea, I'm sure, and if low-class over-the-top hyuck-hyucks are your cup of tea, Yard Dog has more Rand titles too, not to mention such things as *The Four Bubbas of the Apocalypse*. Visit www.yarddogpress.com to see.

* * *

It is something of a cliché to say that dead writers live again whenever someone rereads one of their books. It is also a fond hope of living writers, as Mike Resnick says quite evocatively in "Travels with My Cats," in which an author actually manages to return to prod a loner toward involvement and love. The story is one of twenty to be found in **New Dreams for Old**, a collection that amply demonstrates why Mike has been one of my favorite writers since the 1970s. He has a remarkably clean style and a huge gift for sheer story at many levels. He can be light and frothy as in his John Justin Mallory fantasies (two are here) and deeply reflective about the human condition, as in the Kirinyaga stories (one of the best, "For I Have Touched the Sky," is here). If you aren't familiar with his work, this collection is an excellent introduction. If you are, his stories tend to be very rereadable. Buy this one, and enjoy.

I'm not sure that one can say dead writers also live again when critics discuss their work, but they certainly do when wives and children and friends publish their memories in memoirs and biographies. It is thus a pleasure to see that Isaac Asimov's widow, Janet Jeppson, has been persuaded to write **Notes for a Memoir on Isaac Asimov, Life, and Writing**. It's a slim book, but it is an eloquent reflection on life and love with Asimov and the importance of imagination, reading, writing, philosophy, humor, and more in that life and love. There is also a fair amount of material on Jeppson's own past, which makes the book in part an autobiography. But though she has published her own science fiction—and even rounds out the book with seven short stories that attest to a talent quite strong enough to stand on its own—most who pick up this book will do so for the connection to her late husband. Yet she too will live past her lifetime in her work, and that is no bad thing at all. ■

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BRASS TACKS

Stanley,

I have been an *Analog* subscriber since 1976, and my collection goes back to January 1967.

I read the October 2006 editorial and want to start by setting you straight on some items, because you don't seem to have all the facts.

RFID chips contain *only* a unique id for the product. They do not contain price or any other information. The price is stored in the computer scanning the purchase. I believe current RFID chips store 128 bytes of info. Tracking all the people all the time is not possible.

Let me explain number two so that the masses can understand, because I run into this on so many wacko boards (which is probably where your source for this originated).

In 1992, I was brought into a project to consult on sizing a computer for a project by AT&T. Some sister group in another city wanted to store the entire billing for the AT&T phone network for a three month rolling store, to try and do "what if" questioning against. I quickly did the calculations for them and showed them that the largest computer of the type that *theoretically* existed was 2/3 times the size needed to just store the data. I would estimate that the processor power to load and unload the data and to do the actual searches on it would be 100 to 1000 times what was available. The theoretical computer was six times the size of the largest computer of the type then in existence, and exceeded a hard coded limit in the hardware to boot. The data for each phone call recorded was to be smaller than the size of a current RFID chip, by about 3 to 2.

Okay, it is fourteen years later and computers are bigger and faster. However, at the mainframe level, they don't grow as fast as at the PC level. And today, AT&T could probably *store* the data. But they don't have enough processor to do the "what if" questions against it.

Now, let us fast forward to what you are talking about storing. For every encounter with any item that has an RFID chip, you are going to store 3/2 the amount AT&T was going to store. Thousands and thousands of products. And not just three months of data, *years* of data would have to be tracked to be of any use. All of that would have to be searched together to do any significant searching.

I know, your next thought is to go to "massively parallel" computers. Well, sorry to burst that bubble. The computer we were sizing out in 1992 was a "massively parallel" computer. (Over 1000 processors.)

So, in my professional opinion, the kind of privacy invasion you are talking about in your article is tens or more years away, short of some major groundshaking advance in computer hardware.

You see DARPA was only experimenting with the process of collecting limited amounts of data; they had not stopped to consider the quantity of data they would be looking at.

To give you some perspective. On the 4th of July this year, we had a project to just re-organize data in place (which improves access time). We spent 3.5 hours re-organizing 660 million rows of data. We had a sizable mainframe computer *pegged* for that time (running at 100%,

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just on this task). Now just to read the data, by the standard calculation, would be just over 1 hour. I estimate that the data for storing all the RFID would easily exceed 660 *trillion* rows. A very simple calculation shows that just reading all the data would take the entire output of a single mainframe for something like 1,000,000 hours. Certainly not timely information, as the data would change long before you got a result. And even the federal government cannot afford 100,000 or more mainframes! Or more especially the staff to run them!

James Eager
BS Computer Science, MBA
Data Analyst
Database Administrator

I hope I have sufficiently debunked this "theory" enough to prove to you how foolish this fear is. If you have any questions about how I got to some of these numbers, please ask, but know that I rounded in favor of your premise considerably in each case. In actuality, I suspect the numbers of being orders of magnitude *worse* for the premise.

I find on rereading the editorial that you're right about one thing—I inadvertently made it sound as if the price information was stored in the RFID itself rather than in an external database. That could be done in the future, if anybody wanted to, but it's more expensive, clunkier, and there's no good reason to do it—having only ID on the RFID lets individual stores set prices and change them at will. I knew better, and apologize for the bad wording.

As for the rest, it seems to me that you're basing your argument on obsolete data, a too conservative estimate of how fast things change, and an unrealistically simplistic assumption about how such searches would be done. I asked Edward M. Lerner (who's been researching this stuff now*) for his opinion, and he said:*

"I disagree with Mr. Eager's second statement. Tracking individuals is possible, and will only become easier. I'll argue by reasons of (a) growth in computing, especially since Mr. Eager reasons from a years-earlier study, and (b) disagreement with an assumption in his analysis.

First, growth. Computers keep growing exponentially in their power. Individual processors get faster, demonstrated by the GHz processors now common in PCs (vs. 6 MHz in my first PC). Processors handle more bits in parallel now, with 64-bit processing now common (versus 8 and 16 bits in early PCs). We're starting to see multiple CPUs on a single chip. The number of CPUs in a supercomputer keeps increasing (to 64K, in 2005, in IBM's Blue Gene/L). And beyond supercomputing comes grid computing, in which collaborating organizations harness their computer centers to common goals.

Storage grows rapidly too, and petabyte (one petabyte = 1015 bytes) databases now exist, for example, storing Earth observation data. Addressable memory keeps increasing, too. Those 64-bit processors I mentioned enable 64-bit addressing. 64 bits in an address register can specify any of 264 (1.84 X 1019) locations.

Consider the Large Hadron Collider, nearing completion at CERN. Of most interest to *Analog* readers, LHC may finally detect the Higgs boson, a missing piece from the Standard Model of particle physics. The globally distributed LHC computing grid will store 15 petabytes per year. Physicists will use the computing grid to sift for evidence of specific short-lived particles. (Ref. "Old World, New Grid," *IEEE Spectrum*, July 2006 issue.)

Now extrapolate a few years more. . .

Next, the too restrictive assumption: that data searches always involve brute-force searches of enormous databases. Those who might exploit and abuse the torrents of RFID data will know to orga-

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nize the data as they acquire it. Imagine businesses or transit authorities voluntarily, or under legal mandate, uploading daily data dumps to a government organization.

During data ingest, the uploaded time- and place-stamped RFID readouts can be pre-processed. Linking the data and constructing indices (in geek-speak, metadata) as records are ingested *greatly* simplify hunting for any particular information.

Finally, consider: If a particular tag (say, the RFID tag that uniquely identifies a specific tire) is known to be of interest, the ingest process can flag its appearances *on the fly* as it enters the processing center(s)."

Analog,

I read "Day of the RFIDs" by Edward M. Lerner after reading Stanley Schmidt's editorial on RFID in the October, 2006 issue of *Analog*. The story was enjoyable and Mr. Lerner obviously knows more about RFID than he is telling. While there are concerns with RFID as voiced by Stanley, I do not think that the events in the story will come about and, if they do, there are things that a technically inclined individual can do about it—far beyond what was done in the story.

There is a current fear about a backlash from the public among companies thinking about adopting RFID. This has resulted in legislation in Wisconsin that makes chipping people illegal and there are other legislative actions, which can be found on rfidlawblog.com. As the technology is deployed, more restrictions will be placed on RFID applications.

There are also economic disincentives. A very large company has required RFIDs on all shipping pallets and they have found the following problems:

1. Having RFIDs on pallets has only decreased out of stock rates by only 0.5%.

2. The profit gained by having RFIDs on pallets, after an investment of over five hundred million dollars, was only on the order of just above six million dollars, which is very bad Return On Investment (ROI) for a very large company.

3. Getting read rates for the RFIDs up into the 90% range is a real challenge in the relatively controlled area of a stockroom. The rest of the world is even worse.

Considering the size of the company, which is a multi-billion dollar retailing company, item 1 and item 2 above make smaller companies think five times before implementing a similar system. Bean counters can help your cause as well as hurt it. The current business thinking is to put RFIDs only on big-ticket items and those items that must be kept in stock, such as DVDs and CDs during the first two months after release. The information above can be found on eweek.com.

From a purely technical standpoint, RFID can be defeated quite easily if you have any technical skill. They can detected, rewritten so that you're wearing, say, toilet seats instead of sandals, burnt out (putting them in a microwave is not necessary if you can take a camera apart and solder), shielded (metallized plastic from a potato chip bag works as well as aluminum foil), jammed, and can be used to insert a virus into the reading system. I can foresee electronic countermeasures spreading on the personal level if RFID becomes common. It has been pointed out that the new US passport with the embedded RFID is still a valid travel document even if the RFID should go bad. All of the above methods are available for a search on Google. Use of a proxy in the search is optional. Jim diGriz, we're waiting for you.

Radcliffe Cutshaw
Viola, AR

But remember, these technologies are still quite young!

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Dear Stan,

I always look forward to your editorials and, after many years of reading them, I would like to comment on the current one, "Needle With A Nametag" in the October 2006 issue.

Although I am retired now, I have been an industrial control engineer and I believe that I understand the RFID technology and I have a couple of points to make.

1. RFID tags do not store a lot of data. They store a single identification number similar to the UPC bar code number (it may actually be the UPC number—I don't know) only. The in-store computers can use this number to look up the all the other information about the item such as description and price.

2. Essentially RFID technology is the same technology that is used to "microchip" your pet. The scary thing about this is that *the technology already exists* to put one of the things into the body of every citizen of this country. In fact, it has already been proposed and is being discussed in the halls of government as I write this.

3. When a supermarket customer shops at a certain chain exclusively and uses a "loyalty card," the amount of information that the chain's computers can derive from that data is appalling. Just some of the things they can tell are:

—The number of people living in your home, their races, sexes, and approximate ages.

—Their eating habits, good and bad.

—At least the more common health problems that may afflict them.

—The total income of your household.

—The number of pets you have and what kind.

—Your partying habits: Do you give big or small parties? How often? How wild?

—How many times a year you have visitors and how many visitors.

These are just some of the things they can tell. It doesn't take much imagination to think of others. This gives you just a hint of how much information can be derived about you from seemingly innocent sources.

Nelson Highley
Charlotte, NC

Dear Dr. Schmidt,

I wonder why people, who are so against government gathering information on citizens are still so trusting on governmental gun control. After all, an armed population is the last bastion in the defense against any tendency toward an increasingly tyrannical government!

Andrejs Baidins,
Wilmington DE

Why do you assume they're the same people? ■

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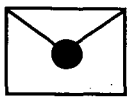

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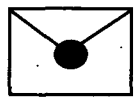

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UPCOMING EVENTS Anthony Lewis

12–14 January 2007
ARISIA '07 (Boston area speculative fiction conference) at Hyatt Regency, Cambridge MA. Writer Guest of Honor: Esther Friesner; Artist Guest of Honor: Hilary Scott. Registration: $35 until 15 December 2006; $40 at the door. Info: www.arisia.org; info@arisia.org; Bldg. 600, PMB 322, 1 Kendall Sq., Cambridge MA 02139.

12–14 January 2007
RUSTYCON 24 (Seattle area SF conference) at Seatac Holiday Inn, Seattle WA. Guest of Honor: Terry Bisson; Artist Guest of Honor: Rob Alexander. Registration $40. Info: www.rustycon.com; PO Box 27075, Seattle WA 98165-1475.

19–21 January 2007
CONFUSION (Michigan area SF conference) At Detroit-Troy Marriott, Detroit MI. Guest of Honor: Elizabeth Moon; Fan Guest of Honor: Bill Higgins; Science Guest of Honor: Paul Myers; Music Guest of Honor: Steve Macdonald; TM: Howard Waldrop. Registration: $30 in advance; $45 at door (checks to AASFA). Info: www.stilyagi.org/cons/2007; ConFusion, Box 8284, Ann Arbor MI 48107.

19–21 January 2007
COSine 2007 (Colorado Springs area SF conference) Clarion Hotel, Colorado Springs CO. Guest of Honor: Connie Willis. Registration: $35. Info: www.firstfridayfandom.org/cosine/.

19–21 January 2007
MARSCON (Tidewater Virginia SF conference) at The Holiday Inn Patriot, Williamsburg VA. Info: www.marscon.net; info@marscon.net; Marscon, 4618 Olde Stone Way, Chesapeake VA 23321.

8–11 February 2007
CAPRICON XXVII: A CELEBRATION OF HIGH FANTASY (Fantasy conference) at Sheraton Chicago Northwest, Arlington Heights IL. Guest of Honor: Lois McMaster Bujold; Artist Guest of Honor: Erin McKee; Fan Guest of Honor: Cat Faber. Registration: $70 at door. Info: http://capricon.org/capricon27; info@capricon.org.

16–18 February 2007
BOSKONE 44 (New England SF conference) at Westin Waterfront, Boston MA. Guest of Honor: David Gerrold; Official Artist: Gary A. Lippincott. Special Guest: Br. Guy Consolmagno, S.J.; Featured Filkers: Lee and Barry Gold. Registration: $44 to 16 January 2007, more at the door. Info: www.nesfa.org/boskone; b44info@boskone.org; Box 809, Framingham MA 01701; fax: (617) 776-3243. ■

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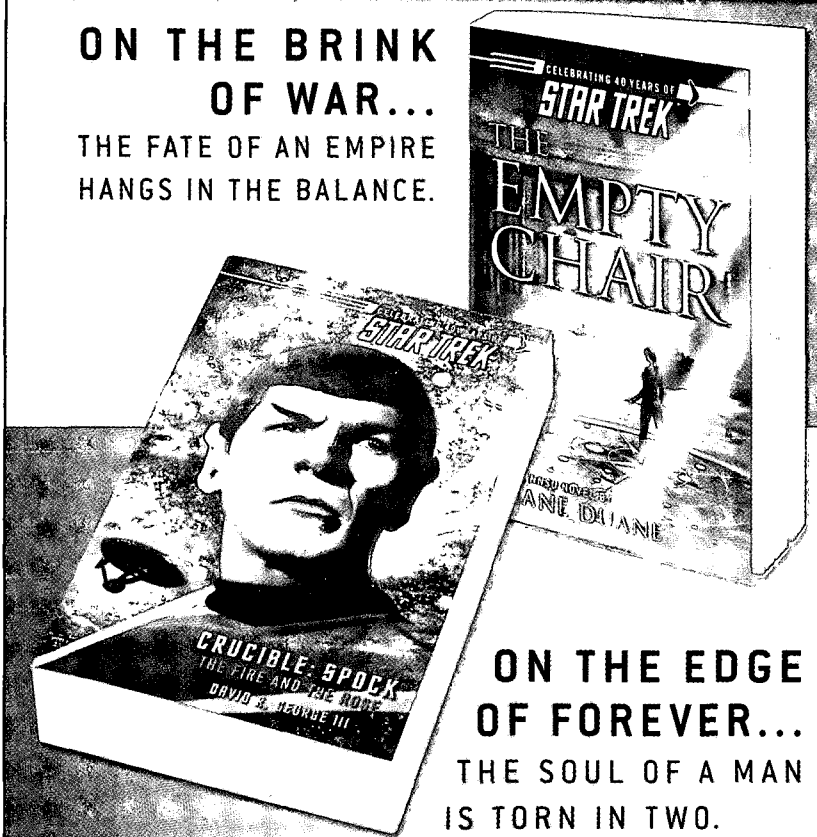

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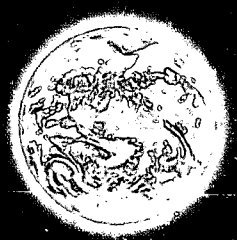

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